Living with Climate Change: Adapting to Water and Wind in Coastal Communities

An Honors Thesis (ARCH 404)

by

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Abstract

Global warming is inevitable in this century. We will experience increased average temperatures, flooding, rising sea level, insect-spread infections, population displacement/eco-migration and an increased number and strength of tropical storms. Coastal areas throughout the world have begun to experience a loss of land due to rising sea levels and are likely to experience more hazardous weather and an increase of flooding. This thesis will explore an architectural approach to the design of a community to adapt to floodwaters and hazardous air movements in order to prevent the displacement of coastal residents.

This coastal community prototype will involve the conceptual design of a community, in the Lower 9th Ward of New Orleans, at two scales of design. First at the scale of the community - looking at the urban plan and topography of a 4.5 square mile area of the Lower Ninth Ward. The second at the scale of an individual residence, a home within the community that will accommodate a family of 4. The residence uses amphibious principles to adapt to changing water levels.

Acknowledgements

I would like to thank all the CAP faculty that helped in the development of this project. Specifically, my advisor Sean Burns and my professor Michel Mounayar who have helped push the limitations of this design and expanded my understanding, philosophy, and appreciation for the design process. Sean Burns has been instrumental in shaping my understanding of the structural capabilities of design and exploring beyond standard structural systems, throughout my time at the College of Architecture and Planning.

Most importantly, I would like to thank my family and friends that have supported me through not only this project, but throughout my college career. Thank you to the family who has given me the love and support through the stressful times, and the friends who were available at all hours of the night to be a sounding board for my ideas. Without the advisors and support systems in my life, this project would not have been possible.

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Process Analysis Statement

The design process of this creative project was conducted over the course of two semesters. The first semester was used for research, programming, and the beginning stages of conceptual design. The second semester was when the majority of the design decision making occurred. Design process is stages of design that occur for a given project. This method of design is used throughout school and the industry.

Predesign is the first stage. It involves research into the leading topics and issues, precedents, site conditions, etc. It is the stage where the necessary information is gathered to begin conceptual design. The research originated with book research on how architecture historically has addressed flooding. Architecture's approach to flooding was further investigated through exploring precedents. While not all precedents had a direct correlation with the this creative project's design, the precedents are necessary for understanding the conditions in different areas, how certain concepts can be feasible, and to gather an understanding of what concepts could be applicable and which concepts are not. Site research was conducted through history research, finding maps and diagrams, as well as a site visit.

A meeting with the nonprofit organization LowerNine.org was instrumental in understanding the local community's culture, something not easily experienced by tourists. The information gathered during predesign is used throughout all future phases.

The next step was schematic design. This is where "big picture concepts" were determined and explored. This process involved taking main ideas and concepts from research and precedents to explore the direction the project could have taken. This exploration was done through a series of sketches and digital models.

Since this creative project is strictly a conceptual project and not going to be built, design development was the final stage of the design process and it encompassed the last semester of the project. This involved exploring small concepts and creating numerous renditions of the same concepts with small changes. At the community scale, sketches were utilized to produce multiple renditions of the site design with minor changes. This method allows for multiple options to be explored and combined to create a cohesive design. The residence

scale was explored through digital models. Each model had slight variations, and all needed to be analyzed for aerodynamics with wind simulations. Digital modeling was used to explore floor plan, foundation, structural, form, and elevation options. The design development was not a linear progression. As a new foundation shape was explored, it meant the floor plan and form among other things would change. Even the site design had to be modified to accommodate the new foundations. This process was a constant back and forth between design factors in order to find a comprehensive and balanced design between nature, site design, and residence design.

Overall, the design process was not a linear progression. New big ideas were introduced during design development and more research was necessary throughout schematic design and design development. As new ideas arose the second semester of the project became a Venn diagram of the three stages rather than just the final stage.

Introduction

Architecture has evolved to minimize its impact on global warming, but according to the National Science Foundation, global warming is already inevitable in the 21st century.[1] Our actions to minimize carbon footprints will only lessen the severity of the overall climate change. Even if all carbon emissions stop tomorrow, global climate change would still take effect. In this century, we will be seeing increased temperatures, flooding, rising sea levels, insect spread infections, displacement/eco-migration and an increased number and strength of tropical storms.[2] Coastal areas have already begun to see some of these effects. Architecture has the opportunity to respond to these new global climate change conditions. How can architecture respond to rising sea levels and flooding to prevent displacement in coastal areas? This investigation focuses on rising sea levels, more dramatic flood seasons, and more hazardous storm seasons.

Definitions

Community - a group of people that reside in the same area with similar characteristics, such as art, music, architecture, beliefs, etc.

Residence - a structure in which one lives

Floodplain - the area adjacent to sources of water, that is subjected to overflow

Amphibious Architecture - structures that are designed to raise and lower with flooding and fluctuating water levels

Climate Change - the change in climate trends due to Global Warming

Issues

Given the investigative question and the impacts of climate change, three main concepts are to be considered.

Flow of Water

Infrastructure is designed to prevent interaction between flood water and structures. When designing, we need to accept the inevitable and design for the natural flow of water.

Aerodynamics

As climate change progresses, the storm seasons are going to involve stronger storms, a higher frequency of storms, and stronger wind speeds. Designing for efficient aerodynamics will promote resistance to wind strengths, reduce damage, and preventing the need for rebuilding.

Culture

Preventing displacement includes, preserving the social and cultural elements of communities. While designing for the above concepts, customization for separate cultures/ civilizations should be accommodated.

Project

This design project will explore this issue through the creation of a coastal community prototype. The coastal community prototype will involve the conceptual design of a community at two scales of design. First at the scale of the community, looking at the urban plan and topography of a 4.5 square mile area of the Lower Ninth Ward. The second at the scale of an individual residence, a home within the community that will accommodate a family of 4. The goal of this thesis project is to define a set of design principles that can be applied to any buildings in the community to comfortably mediate the effects of rising sea level and increased air movement.

1. "Climate Change Inevitable in 21st Century." NSF. Last modified March 17, 2005.
2. "The Effects of Climate Change." NASA. NASA, July 9, 2019. https://climate.nasa.gov/effects/.

Background

When looking into the future of sea level and flooding, it is important to investigate how flooding has already been addressed. One of the first methods was a sacrificial first floor. This was often used for older homes in areas subject to flooding. "When a storm of major proportions is imminent, the family simply gets in the car, drives to a high location to stay with friends or in a motel or refugee center, and after the storm recedes, returns to the house to clean out the mud and wash the walls and floor of the first floor."[3] While this worked for older homes, it is not efficient or safe to live a home with constant water damage. So, "a sacrificial floor on new structures built in flood plains is no longer acceptable under the National Flood Insurance Program."[4] New construction is suggested to use a raised housing option.

Two types of raised houses were used for flood prone areas. The first is built up sites, which consists of bringing in dirt to bring the site elevation above the base flood level where piles would not be necessary. "The foundation must be engineered so that any erosion of fill that is placed around or under the structure would not endanger the foundation itself."[5] Therefore, it is not allowed in a type V area as the severe conditions would compromise the foundation. The second raised housing technique is pole houses. Pole Houses consist of building the house on columns to elevate the floor of the house above the base flood level. This is the more common type of raised housing because "NFIP requires that all new buildings, substantially damaged buildings, and substantially improved buildings in Coastal High Hazard Areas V zones be elevated to or above the base flood elevation (BFE) – or DFE as determined by local regulations – on open foundations consisting of piles, posts, piers, or columns."[6] These techniques are how architects have responded to flooding where it is inevitable.

New technology has developed to design structures to accommodate flood prone areas. Amphibious Architecture is one of the leading construction methods to combat flooding. This method has been used in the Netherlands for over 10 years. It consists of architecture that rises with flood levels and is anchored to solid ground. Overall designs

have been successful. The amphibious community of Gouden Kust has performed as expected after major flooding. Almost all amphibious structures are residential, but there are several floating structures that are commercial or institutional. There are several built applications of amphibious architecture and several theoretical propositions.

The main method of amphibious architecture relies on guidance post systems. This is the most popular system. As structures remain in place and flood levels recede, the structure returns to its original location on solid ground. The system is based on "four guidance poles [...] located close to the corners of the house, proposed as telescoping tubes of new structural composites of recycled materials that do not corrode."[7] This allows for a stable foundation and for the function of the house to still be available throughout flooding. Very few tests of amphibious architecture have been tested in the United States because the style is not recognized by the National Flood Insurance Program, so it is not covered.

Floating housing, while not technically part of amphibious housing, does use similar principles to float on the water's surface. It resembles land-based dwellings but floats on water. They can be anchored but do not have to be. However, the legal status of such a structure is based on if it is anchored. These types of structures have been built in areas around New York, Seattle, and San Francisco and use similar building methods that traditional residential architecture uses. "The foundations of a land-based property have their counterpart in the water dwelling's several versions of floating base; the traditional concrete and, increasingly, foam and plastic."[8] The foam and plastic help promote buoyancy.

3. Orrin H. Pilkey, Coastal Design: a Guide for Builders, Planners, and Homeowners (Chapman & Hall, 1983), 67.
4. Pilkey, Coastal Design, 67.
5. Donald Watson and Michele Adams. Design for Flooding: Architecture, Landscape, and Urban Design for Resilience to Flooding and Climate Change (Hoboken, NJ: John Wiley, 2011), 173.
6. Watson and Adams, Design for Flooding, 173.
7. Watson and Adams, Design for Flooding, 246.
8. Anne Loes Nillesen, Flüggen Gregor, and Jeroen Singelenberg, Waterwonen in Nederland: = Amphibious Housing in the Netherlands (Rotterdam: NAi Uitg., 2011), 23.

Precedents

Gouden Kust: Maasbommel, the Netherlands

This amphibious housing community consists of 34 amphibious and floating houses. While the highest water level experienced by the community is +5.1 meters, the structures themselves can accommodate +7.1.[9] The dyke serves as a method of containing and providing services such as water mains and electricity. The dykes themselves are not connected to the structures so in cases of flooding the houses cannot be occupied.[10] This community serves to evaluate the connection between structures and the land. Supplying utilities through the dyke with flexible conduits offers potential for large scale applications.

Figure 1: Gouden Kust Flooded

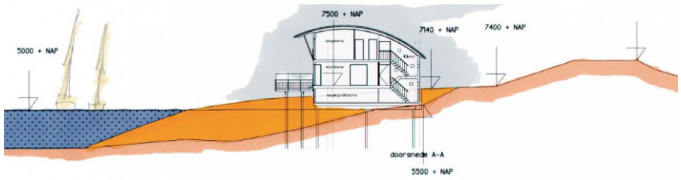


Figure 2: Gouden Kust Land-Based Section

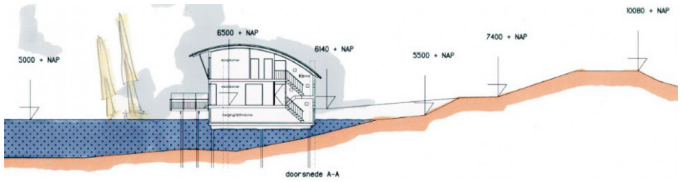


Figure 3: Gouden Kust Water-Based Section

FLOAT House: New Orleans, LA

The FLOAT House is a prefabricated amphibious design by Morphosis Architects. The structure of the FLOAT house is based on a guidance post system. It can float up to twelve feet above ground level, and the guideposts are anchored to the ground by two concrete pile caps supported in turn by six 45-foot deep piles.[11] The foundation structure is pre-fabricated as a single unit of expanded polystyrene and glass fiber reinforced concrete.[12]

Figure 4: Float House

The Amphibious House:

Buckinghamshire, United Kingdom

The Amphibious House by Baca Architects is the first of its kind in the United Kingdom. This is the first amphibious design that includes a basement. Designs often do not include them because the basement would be below the water table, but with this foundation system the dock and hull allow for added square footage while being able to raise 2.7m.[13]

The wet dock is formed by steel sheet piling and reinforced concrete. The slab is permeable concrete supported by concrete piles. This is what carries the weight of the structure in dry conditions. The basement walls are constructed of reinforced waterproof concrete, and flotation elements are situated between the first level and basement, to keep the basement underwater during flooding periods.[26]

Figure 5: The Amphibious House

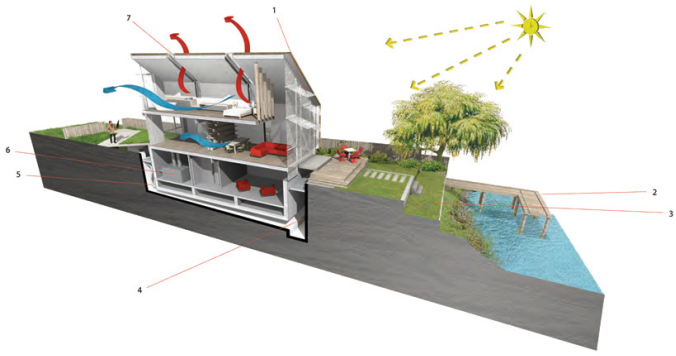


Figure 6 (above): Structure Section
Figure 7 (below): Structure during Flooding

9. Nillesen, Gregor and Singelenberg, *Waterwonen in Nederland*, 57.
10. Nillesen, Gregor and Singelenberg, *Waterwonen in Nederland*, 61.
11. Watson and Adams. *Design for Flooding.* 244.
12. Jonathan Alarcon, "The FLOAT House - Make It Right / Morphosis Architects,"
13. Construction21, "The Thames Amphibious House - Construction21," construction21.org, accessed November 6, 2019, https://www.construction21.org/case-studies/h/the-thames-amphibious-house.html)
14. Construction21, "The Thames Amphibious House - Construction21,"

Bibliography

Alarcon, Jonathan. “The FLOAT House - Make It Right / Morphosis Architects.” ArchDaily. ArchDaily, August 2, 2012. https://www.archdaily.com/259629/make-it-right-house-morphosis-architects.

Nillesen, Anne Loes, Flüggen Gregor, and Jeroen Singelenberg. *Waterwonen in Nederland: = Amphibious Housing in the Netherlands*. Rotterdam: NAi Uitg., 2011.

Pilkey, Orrin H. *Coastal Design: a Guide for Builders, Planners, and Homeowners.* Chapman & Hall, 1983.

Watson, Donald, and Michele Adams. *Design for Flooding: Architecture, Landscape, and Urban Design for Resilience to Flooding and Climate Change*. Hoboken, NJ: John Wiley, 2011.

Construction21. “The Thames Amphibious House - Construction21.” construction21.org. Accessed November 6, 2019. https://www.construction21.org/case-studies/h/the-thames-amphibious-house.html.

NASA. “The Effects of Climate Change.” NASA. NASA, July 9, 2019. https://climate.nasa.gov/effects/.

National Science Foundation. “Climate Change Inevitable in 21st Century.” NSF. March 17, 2005. https://www.nsf.gov/news/news_summ.jsp?cntn_id=103108.

Figure Credits

1. *Flooding*. Climate ADAPT, April 29, 2016. https://climate-adapt.eea.europa.eu/metadata/case-studies/amphibious-housing-in-maasbommel-the-netherlands.

2. *Section of the Floating House.* Urban Green - Blue Grids. Accessed October 2, 2019. https://www.urbangreenbluegrids.com/projects/amphibioushomes-maasbommel-the netherlands/.

3. *Section of the Floating House.* Urban Green - Blue Grids. Accessed October 2, 2019. https://www.urbangreenbluegrids.com/projects/amphibioushomes-maasbommel-the netherlands/.

4. Baan, Iwan. *The FLOAT House. The FLOAT House - Make It Right / Morphosis Architects.* ArchDaily, August 2, 2012. https://www.archdaily.com/259629/make-it-right-house-morphosis-architects.

5. *The Amphibious House. Global Possibilities*. Accessed November 6, 2019. https://globalpossibilities.org/baca-architects-amphibious-house-protects-inhabitants-from-flooding/.

6. *Building Systems, Global Possibilities*. Accessed November 6, 2019. https://globalpossibilities.org/baca-architects-amphibious-house-protects-inhabitants-from-flooding/.

7. *Section Highlighting the Level Change in Response to Flooding. Global Possibilities*. Accessed November 6, 2019. https://globalpossibilities.org/baca-architects-amphibious-house-protects-inhabitants-from-flooding/.

Site: Lower 9th Ward, New Orleans, LA

For proper exploration into the prototype community, the site needed to fulfill several factors. The first factor requires the site to be in a coastal area. With current sea level rise trends, the site's elevation needs to be at sea level. To address the changing storm seasons, potential sites need to experience hurricanes. The final factor for the prototype community's site needs to be a history of flooding.

The Lower 9th Ward of New Orleans fulfills all of these criteria. It is not only in a coastal region, but is also located at the delta of the Mississippi river and surrounded by water on three sides by the Mississippi River, the Main Outfall Canal, and the Industrial Canal. The elevation of the designated area ranges from 3 feet below sea level to 8 feet above sea level. The north end of the site, bordering the Main Outfall Canal, has the lower elevations increasing while moving south. And finally, Hurricane Katrina in 2005 led to one of the worst flooding events in New Orleans history. Several blocks of the Lower 9th Ward were covered in over 8 feet of water. Even during heavy rain events, roads begin to flood over.

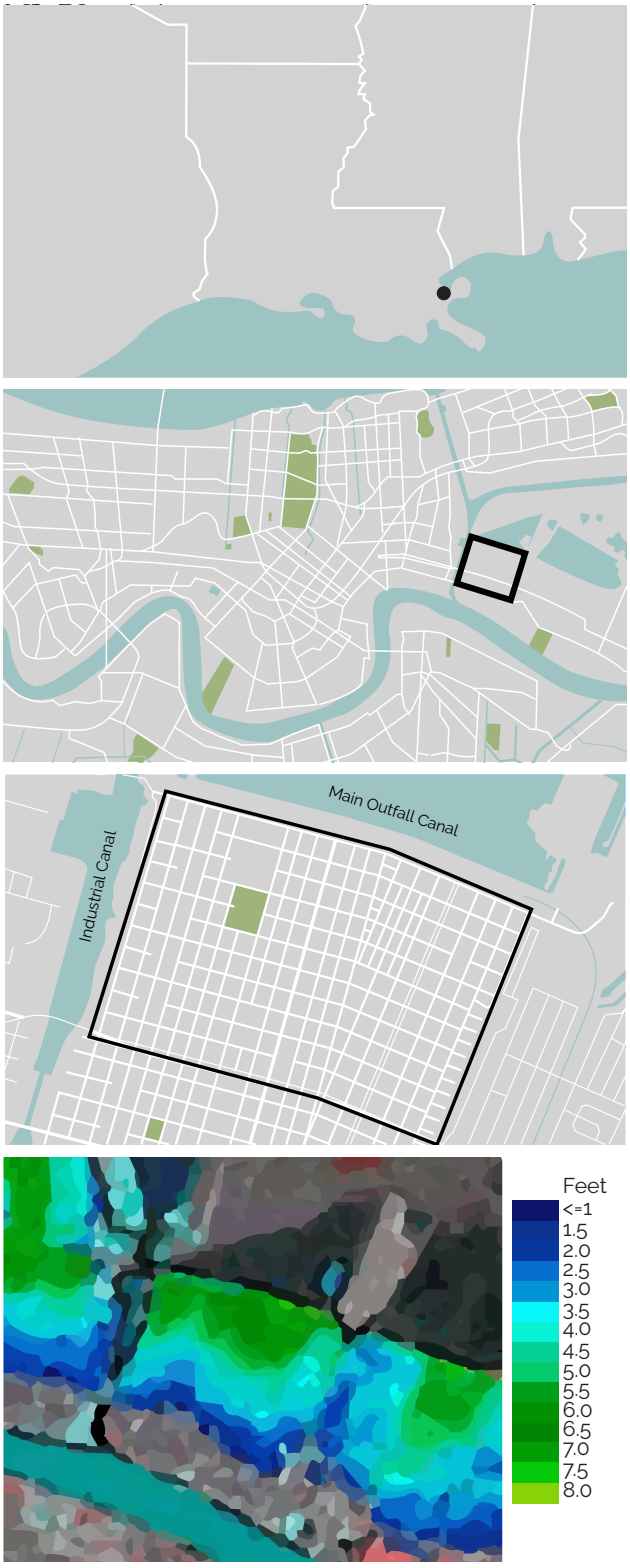


Figure 1: Estimated Water Depth on 9-02-2005
[Graphic Style Edited]

The U.S. Army Corps of Engineers has created a system of canals and levees to control water around the city. The Lower Ninth Ward is surrounded by flood walls and levees on three sides, two of which are directly adjacent to the community site. The arrows on the above map signify locations of breaches during Katrina. These breaches are what led to the extreme flooding in the Lower 9th Ward.

Homes in the Lower 9th Ward are typically small single family residences. The traditional style is the shotgun house. This style uses a linear organizational system and often varies in color.

New Orleans' culture showcases the arts with jazz street music, street murals, and a multitude of colors. These shared characteristics create a closeness and connection between neighbors.

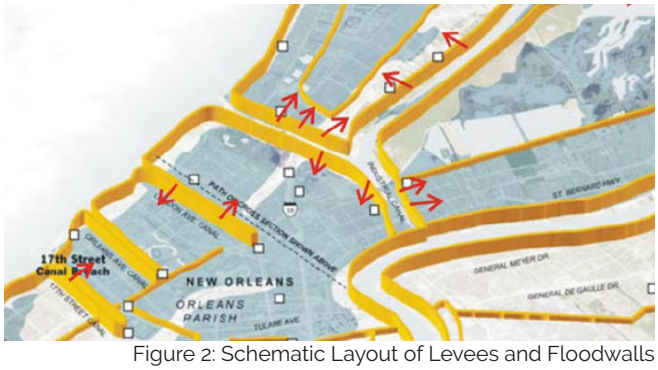


Figure 2: Schematic Layout of Levees and Floodwalls


Figure 3: New Orleans Musicians' Village

Figure 4: New Orlean's Street Band

Figure 5: New Orlean's Street Art

Assumptions

The extensive systems of flood walls throughout New Orleans regulates water's movements. The walls surrounding the Lower 9th Ward restrict flood water's natural flow. To promote incorporating water's fluidity, this project is moving forward with the assumption that the flood walls have been removed.

Given current sea level trends in New Orleans, this project is assuming 12 inches of sea level rise.

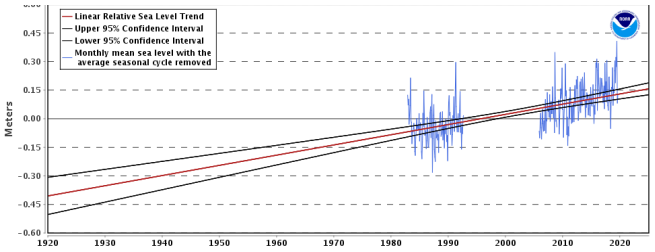


Figure 6: New Orlean's Relative Sea Level Trend

Given the current flood zones and flood zone trends in New Orleans, this project is assuming the common flood zone to be 2 feet, and an extreme flood zone of 5 feet.

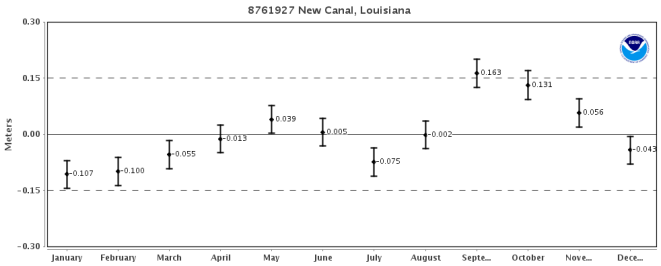


Figure 7: New Orlean's Average Seasonal Water Level Cycle

Goals

To properly explore the impact of the concepts for this project, there are several goals the design aims to achieve.

The first goal is to promote full circulation throughout the community up to 7 feet of flooding. This will allow occupancy and use of the community throughout extreme flood periods.

The second goal is to preserve structures from flood damage up to 8 feet above the extreme flood zone.

The third goal is to minimize wind pressure on individual structures. Form design will impact the efficiency of the aerodynamics of wind around the structure. A more efficient form will result in lower static pressure on the structure's surface.

The fourth goal is to allow structures to be customized to an individual's preferences, by color, art, vegetation, etc.

Program

Community

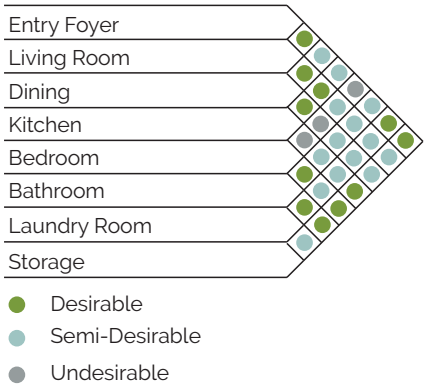
While the community design is strictly a conceptual part of the project, there are specific building typologies that should be supported and enough residential units to maintain at least the current population of the area. This involves creating an urban center that can offer educational services, emergency services, commercial locations, and places of worship.

Currently, emergency services such as police, fire department, and EMTs, have limited access to the Lower 9th Ward by movable bridges, sometimes leaving the area without these services for hours at a time. Therefore, adding these services is a necessity.

The desired quantity of residential units is approximately 1,200. Each should have access to a community park/green space, to promote the community atmosphere of the New Orleans area.

Residence

The single-family dwelling requires efficiency between certain areas, while also avoiding certain connections. These adjacencies are to allow for open connections while still allowing for privacy.



Based on the average sizes and accommodations of homes currently in the Lower 9th Ward, the residence will have 1,200 sqft. Within this the current accommodations will be available:

- 1 Bedroom | ~150sqft
- 2 Bedroom | ~100sqft each
- Living Room | ~240sqft
- Kitchen | ~140sqft
- Dining Room | ~100sqft
- Laundry Facility | ~40sqft
- 2 Bathroom | ~40sqft

Design Process | Community

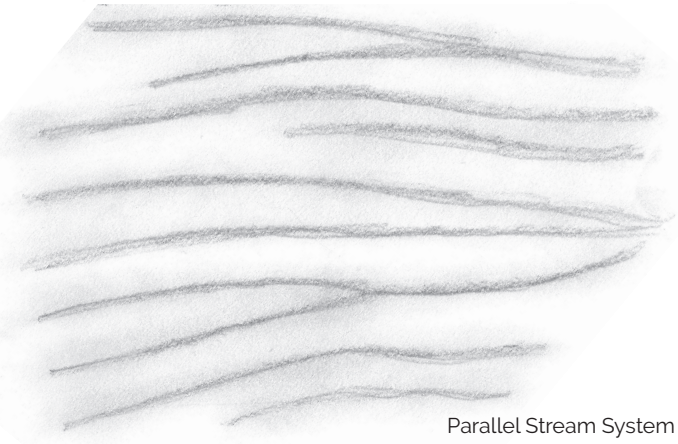
The community design explores creating a system of circulation while providing individual lots for buildings. The circulation looks at the potential for maintaining a vehicular mode of transportation, a pedestrian based mode, and a mixture of the two.

Hydrology

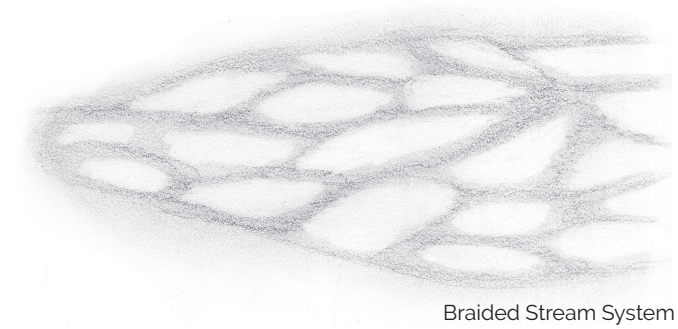
The first concept looks at the natural behavior of water, specifically stream patterns. By looking at the rectangular, pinnate, and dendric stream patterns, an organizational pattern of raised roads with structures within the flood zone can be determined. This design allows for the front porch culture of New Orleans, while allowing for commercial or community areas at diverging points. Each stream pattern can serve as the inspiration for different designs. By understanding how water moves and erodes the earth, the community design can accommodate those erosion tendencies.

Figure 8: Erosion

Dendric Stream System

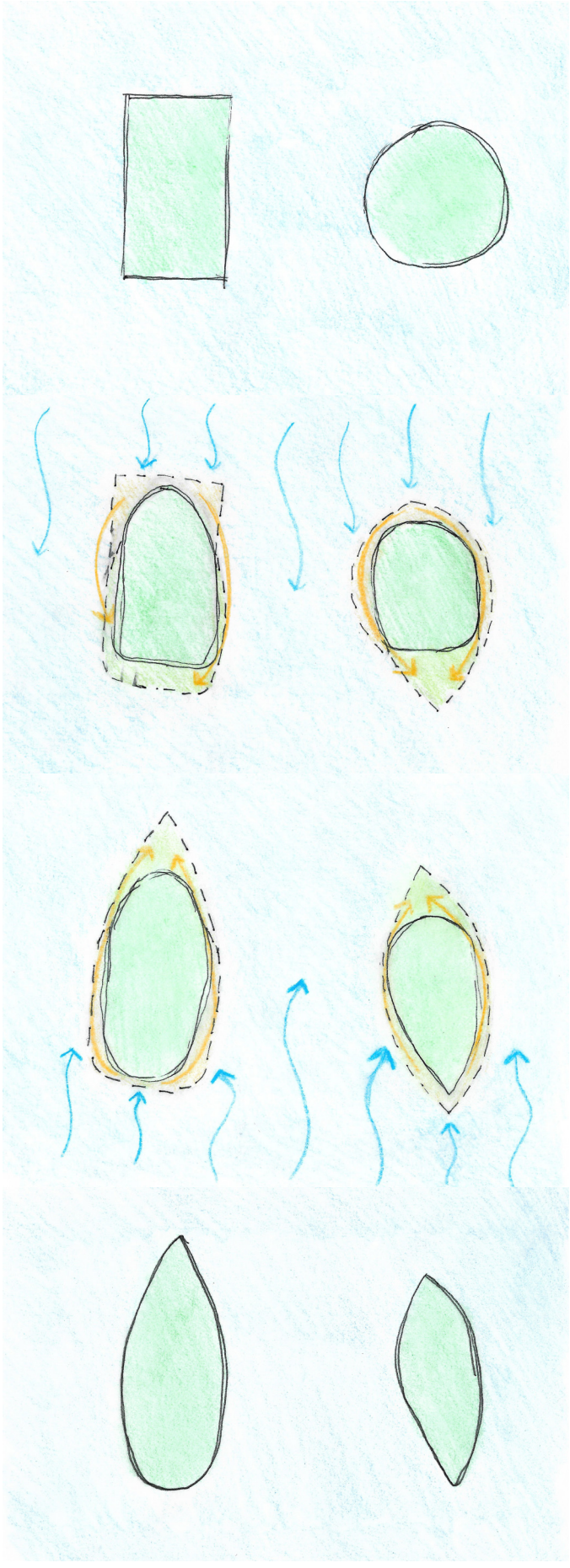


Parallel Stream System



Braided Stream System

The following images present studies into how earth is eroded from advancing and retreating water, such as those in flood plains. The shapes created become thinner and more tear dropped as water moves. Even as earth moves to form new shapes, some is lost to the water movement, shrinking the size of the island.

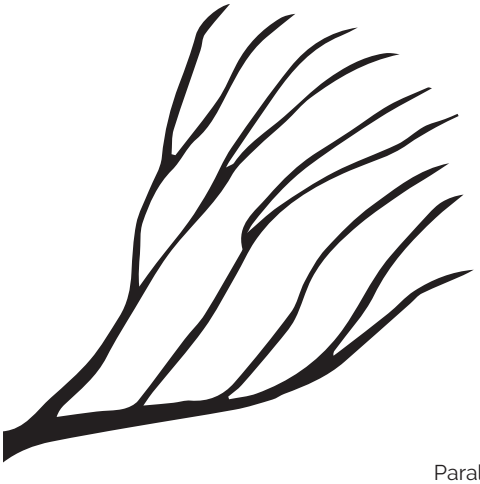


Parallel Stream Systems

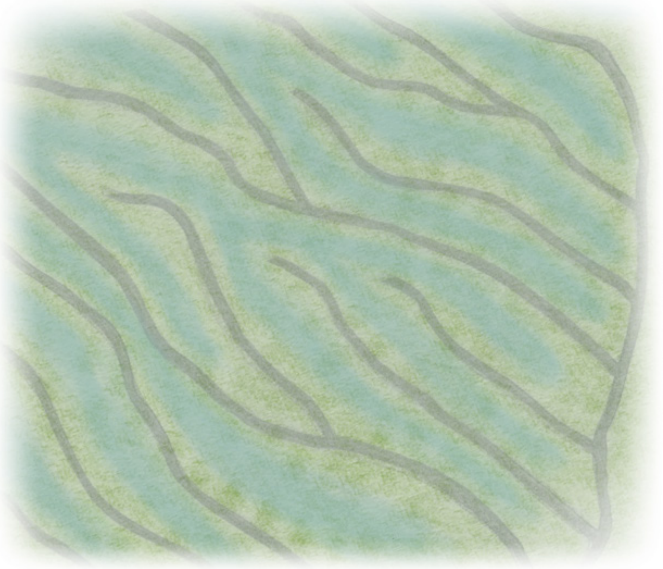
The first explored hydrology pattern was based on parallel streams. The pattern was used to explore how roadways could be organized. This allowed for a design that relied on built up earth to support circulation. This raised earth represents the negative image of the parallel system.

The design relies on the structures being in a linear arrangement around the roadways, on the lower elevations. All circulation and vehicles would remain on the elevated pattern. Water could flow throughout the site on the lower elevations.

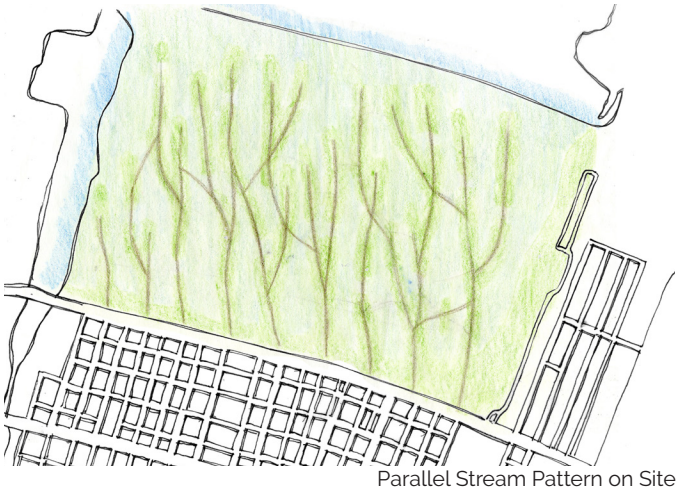
The pattern was then evaluated on the Lower 9th Ward site. While the elevation managed the flood plain, the circulation throughout the site was limited. It left dead ends, and a lack of connections between roadways. This design also lacked the space for community parks that would be accessible during flood periods.



Parallel Stream



Parallel Stream Pattern



Parallel Stream Pattern on Site

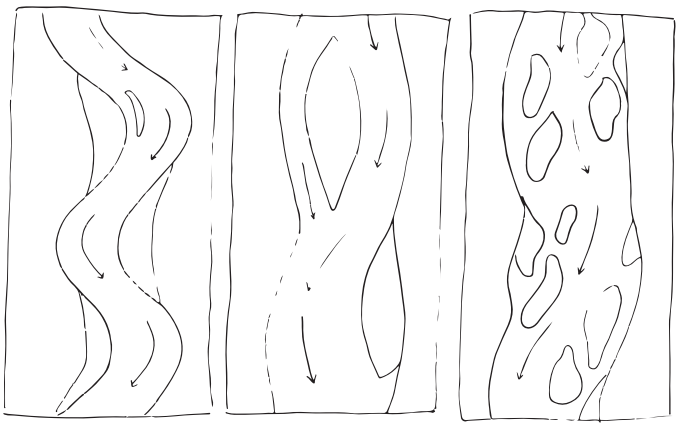
Braided Stream Systems

The next pattern explored was based on braided streams and how erosion carves and moves the earth. This system is based on a system of “islands” that are connected through bridges. This allows water to circulate around the islands and under bridges to flood the area.

This design relies on the islands being the elevated areas. Structures would be arranged on the exterior of the islands on the lower elevation. The islands themselves would contain circulation, community parks, and some structures.

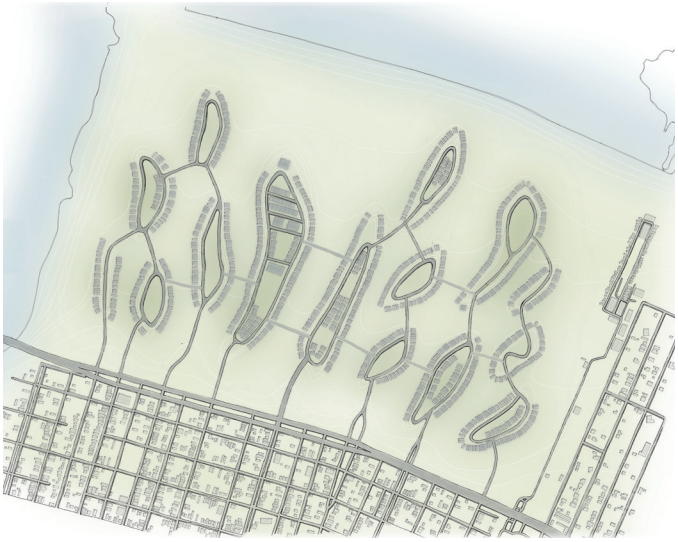
The initial application of this pattern on the site utilized numerous small islands throughout the area. This resulted in a complicated cluster, reducing space between islands for water movement, and causing inefficient vehicular circulation.

The second rendition of this pattern involved larger islands that allowed for more space for community gardens and parks, while simplifying circulation.



Braided Stream Formation

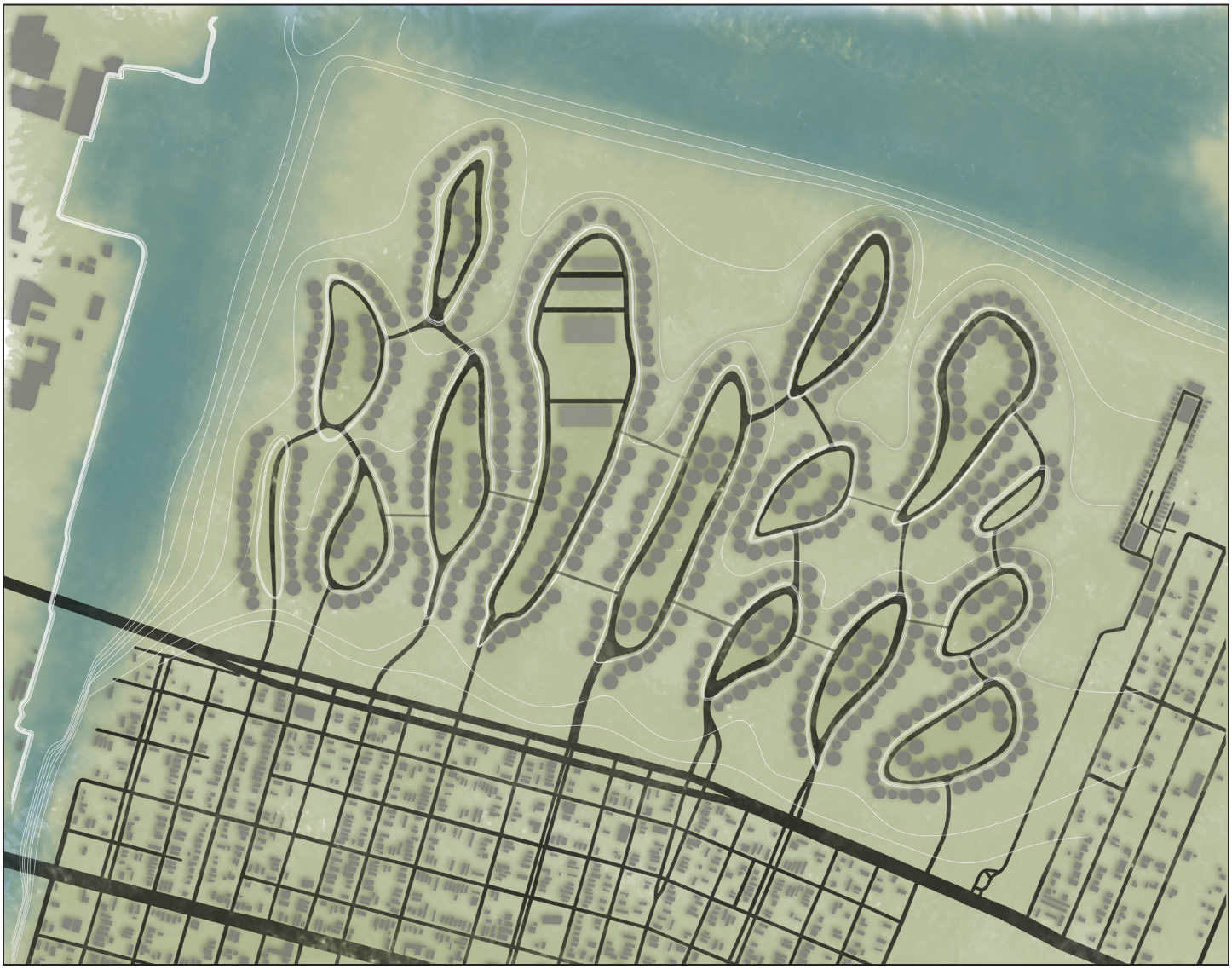
Braided Stream Pattern on Site



Braided Stream Pattern on Site_Second Rendition

Comprehensive Site Plan

The comprehensive design follows the second rendition of the braided stream pattern. Islands have been enlarged for larger structural foundations. The community maintains the current population of the Lower 9th Ward.



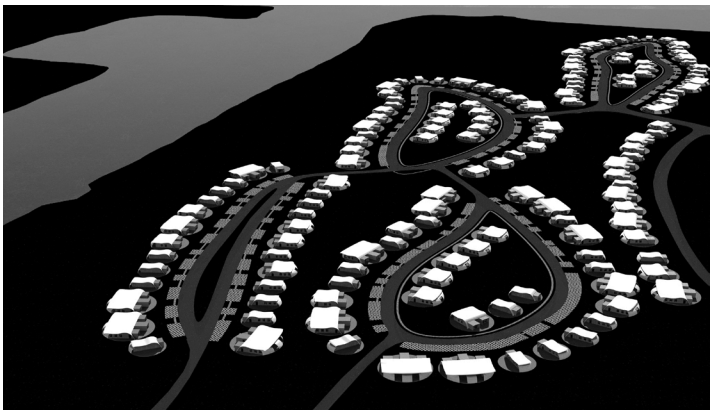
Comprehensive Site Plan

The islands allow for smaller communities within the full community. Enlarging these islands offered space for more interior structures along with the community gardens and parks.

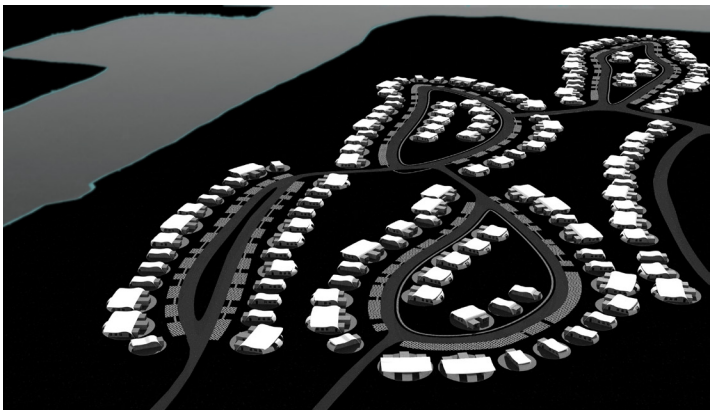
Island Site Plan

Flood Progression

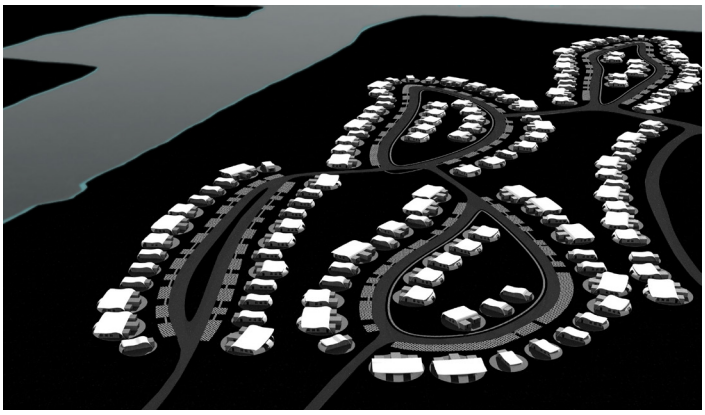
Sea Level



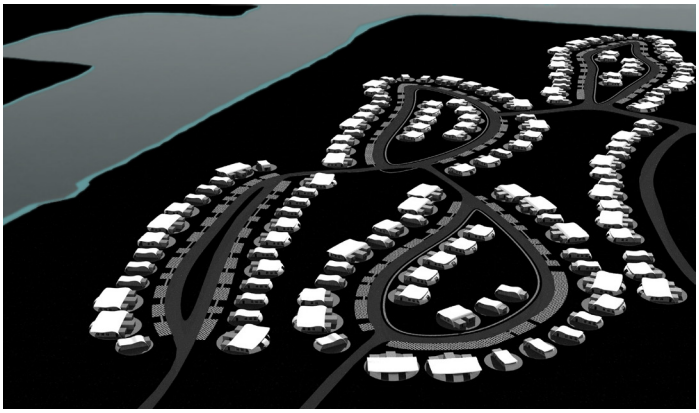
1' Flood



2‘ Flood



3’ Flood



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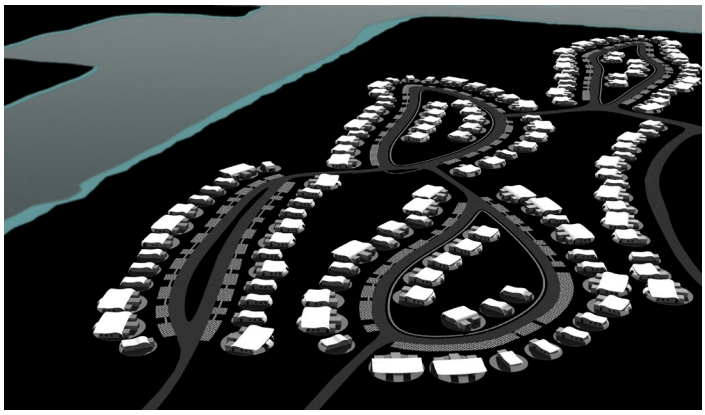
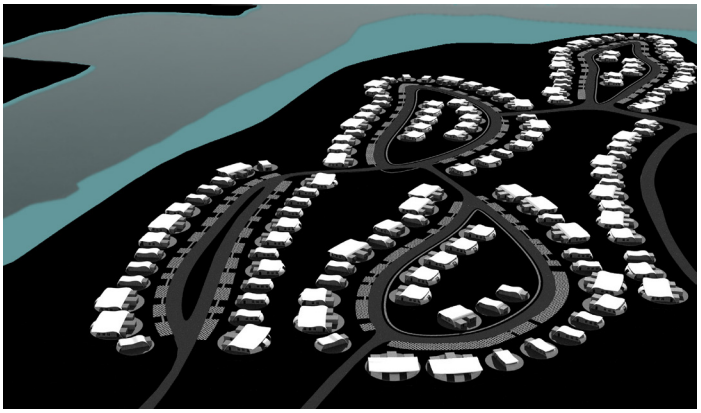
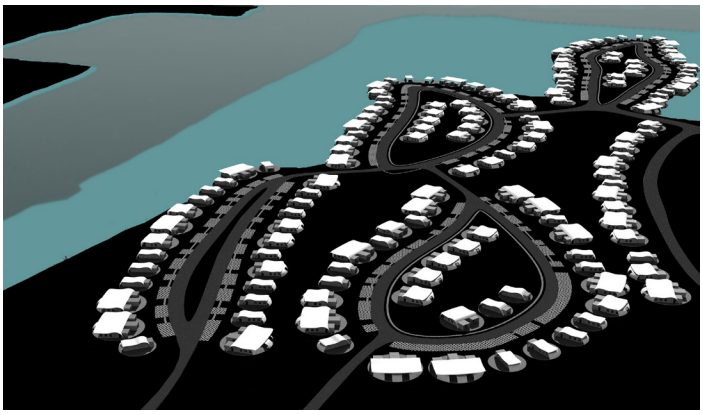


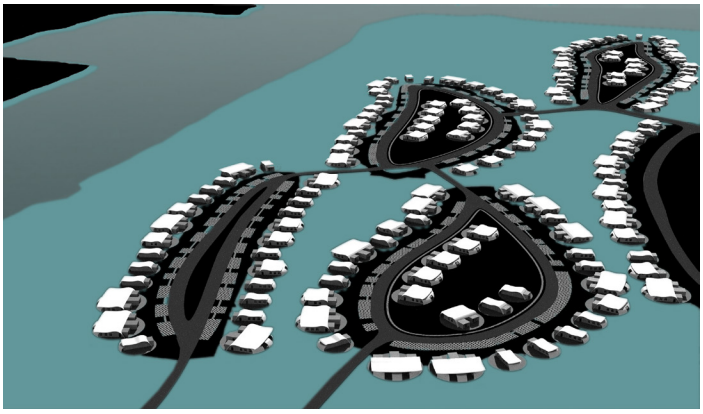
5’ Flood



6‘ Flood



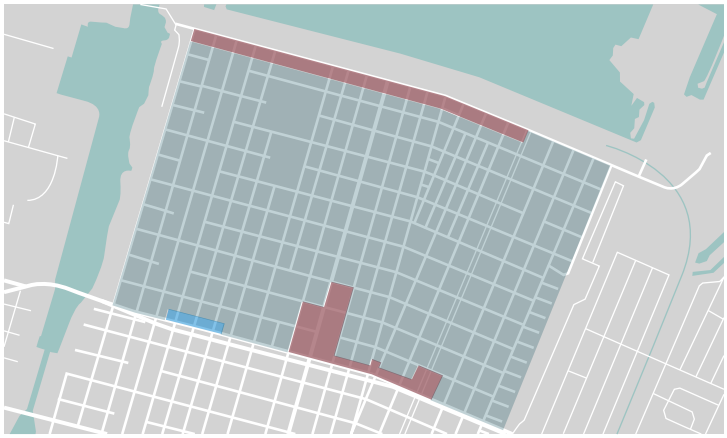
7’ Flood



Zoning

Currently three zonings make up the Lower 9th Ward. The area is primarily residential, with minimal commercial facilities. All areas support community parks and gardens, but in order to provide emergency services, the General Commercial District would be required.

To maintain the current population, the area needs to remain primarily as the Historic Urban Two- Family Residential District. The desired urban center needs to be centrally located to offer efficient access for emergency services throughout the site.

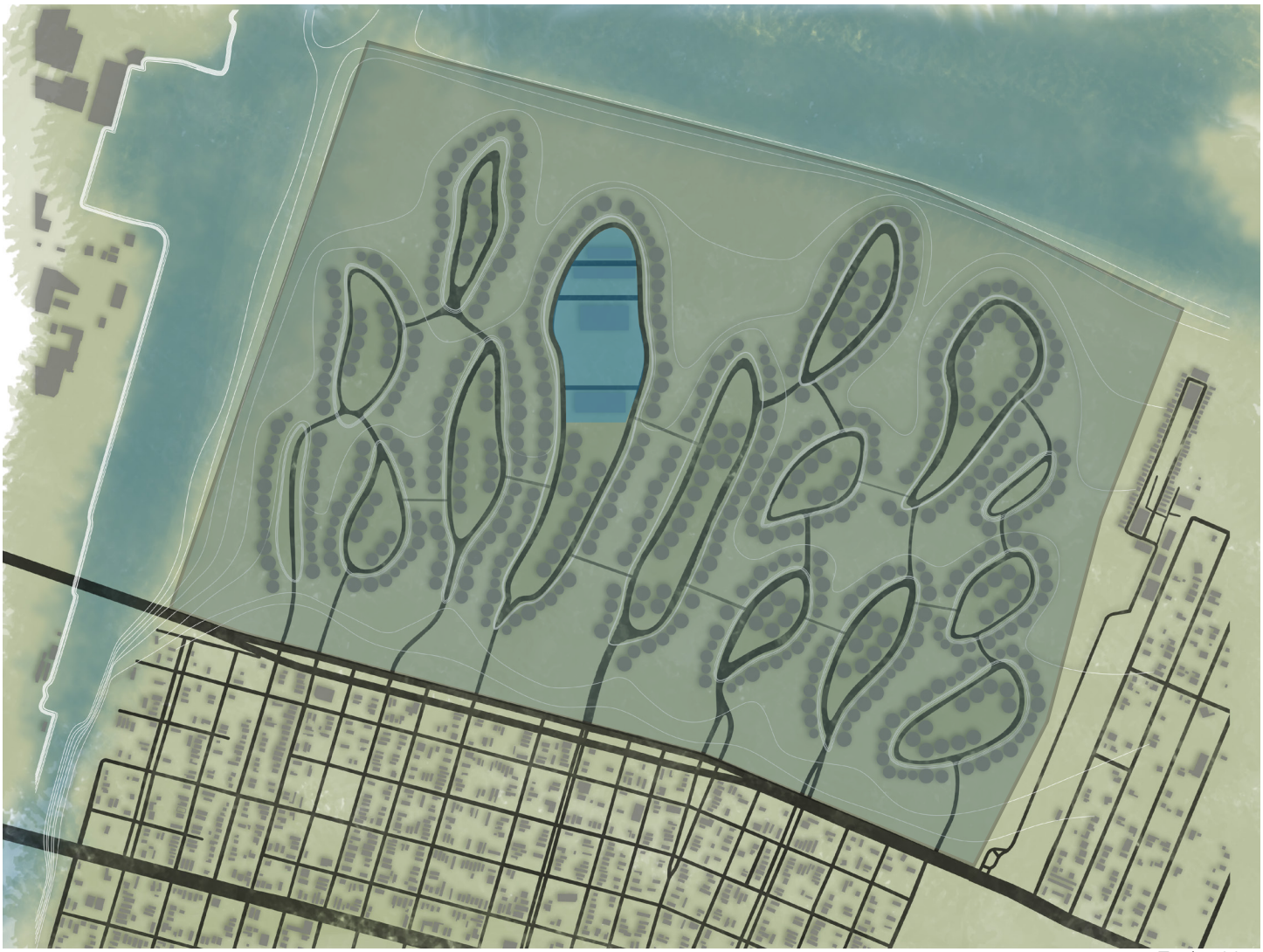


Existing Zoning in the Lower Ninth Ward

- Historic Urban Two - Family Residential District | HU-RD2
- General Commercial District | C-1
- Suburban Business District | S-B1

	C-1	S-B1	HU-RD2
Art Centers	●	●	
Pet Services	●	●	
Day Care Facilities	●	●	●
Health Centers/Services	●	●	
Offices	●	●	
Restaurants	●	●	
Government Offices	●	●	●
Single & Two-Family Dwellings			●
Residential Care Facilities	●		●
Places of Worship	●	●	●
Community Centers	●		
Educational Facilities	●		
Agricultural - no livestock		●	●
Parks & Playgrounds	●	●	●
Stormwater Management	●	●	●

Building Types Allowed in City Zones



Zoning Map

Circulation

Vehicular Circulation throughout the site follows the boundaries of the islands as well as a series of bridges connecting the island. Vehicular travel is primarily in north to south directions. These designed roads connect with major roads at the edge of the site.

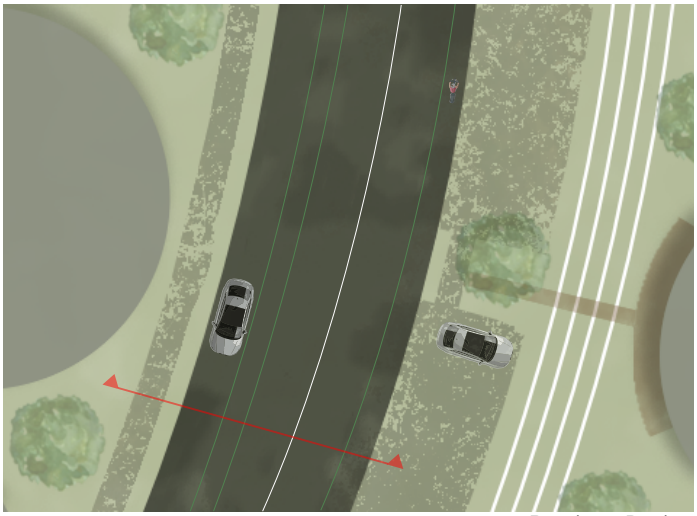
Pedestrian and cyclist circulation follow the roadways as well as a series of bridges running east and west. These bridges allow for circulation not offered by vehicle, aiming to promote non-vehicular modes of travel. While these bridges are not meant to be used for cars and trucks, they are designed to structurally support them so emergency vehicles can have more efficient pathways.

Water movement throughout the site is started on the northern outfall canal and the western Industrial Canal. Based on the topography, water flows around the islands and slowly moves south through the site.

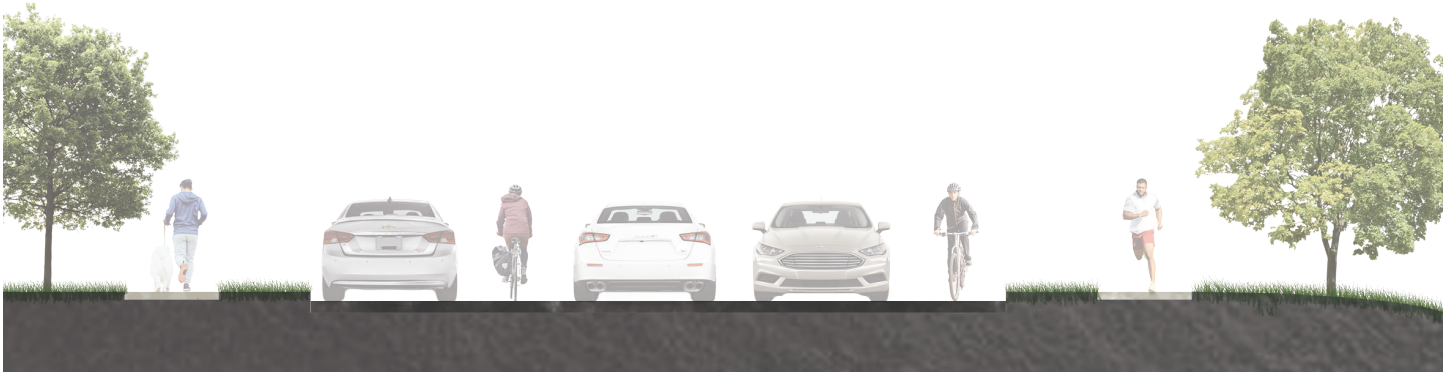
Vehicular Circulation

Pedestrian and Cyclist Circulation

Water Circulation



Roadway Design



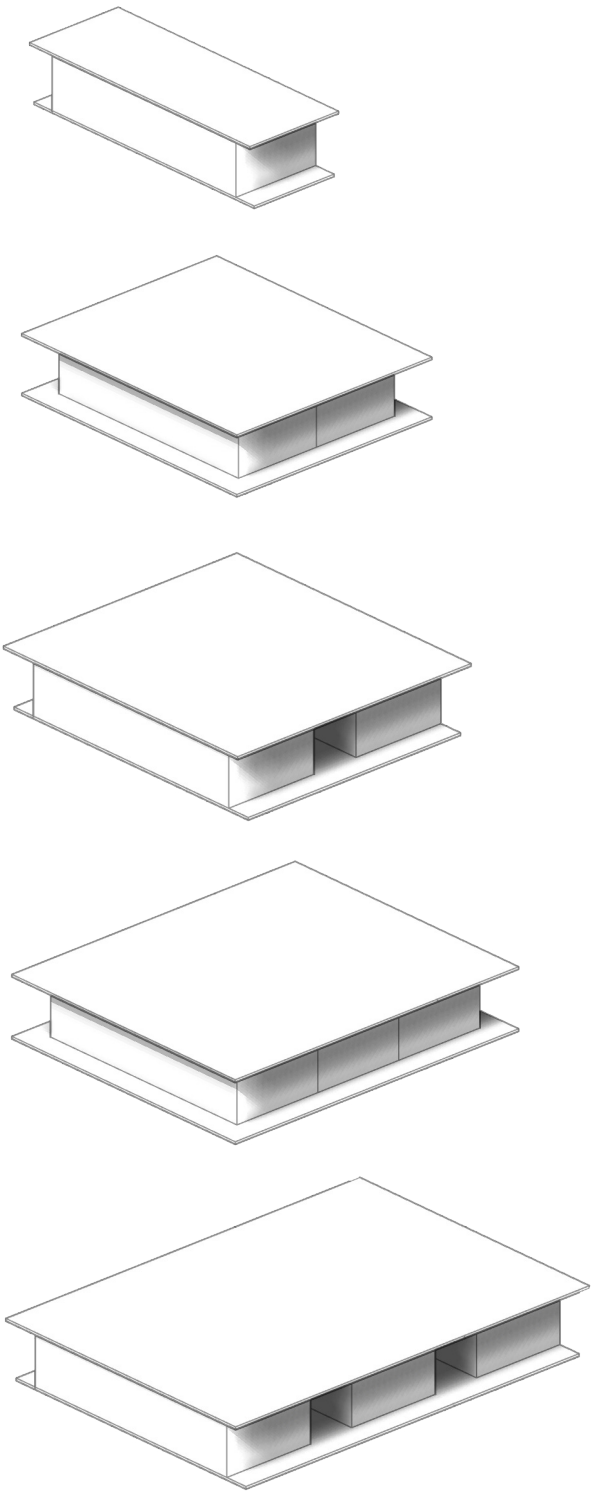
Street Section

Design Process | Residence

The second scale of design is an individual residence, a home within the community that will accommodate a family of 4. The form and structure are designed to comfortably mediate the effects of rising sea level and increased air movement.

Multi-Unit Design

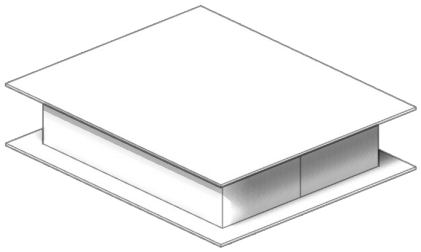
The community design is composed of single, double, and triple units. Each unit serves a single family, estimating for a family of 4. Different unit options allow for individuals to choose their preferred level of privacy. The triple and double structures provide a community between those within that structure, while single unit structures allow for privacy.

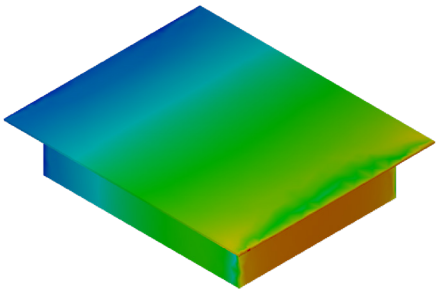


Double and triple unit structures had two arrangements that were evaluated. The first involved the units having a shared wall. The second had a shared exterior space between the units.

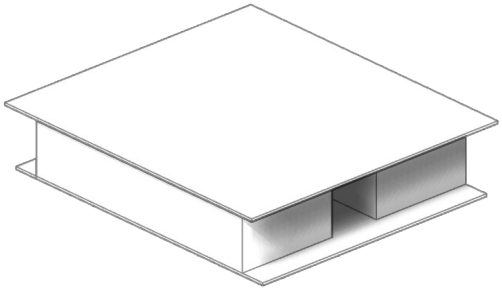
Aerodynamics was the determining factor for the best arrangement. The arrangement with the exterior space allowed for air movement to escape between the units, reducing the static pressure.

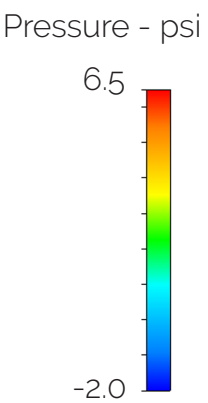
The double-unit structure was used to further the residence design to allow for the exploration of the shared structure and space.

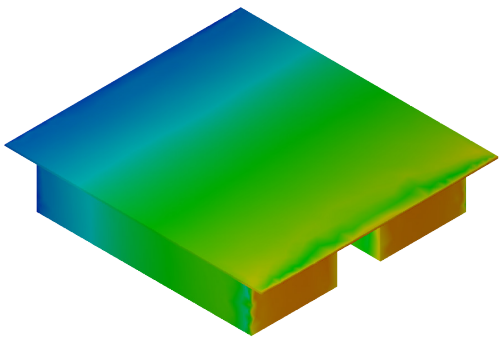




Highest Pressure: 6.51415







Highest Pressure: 5.88339

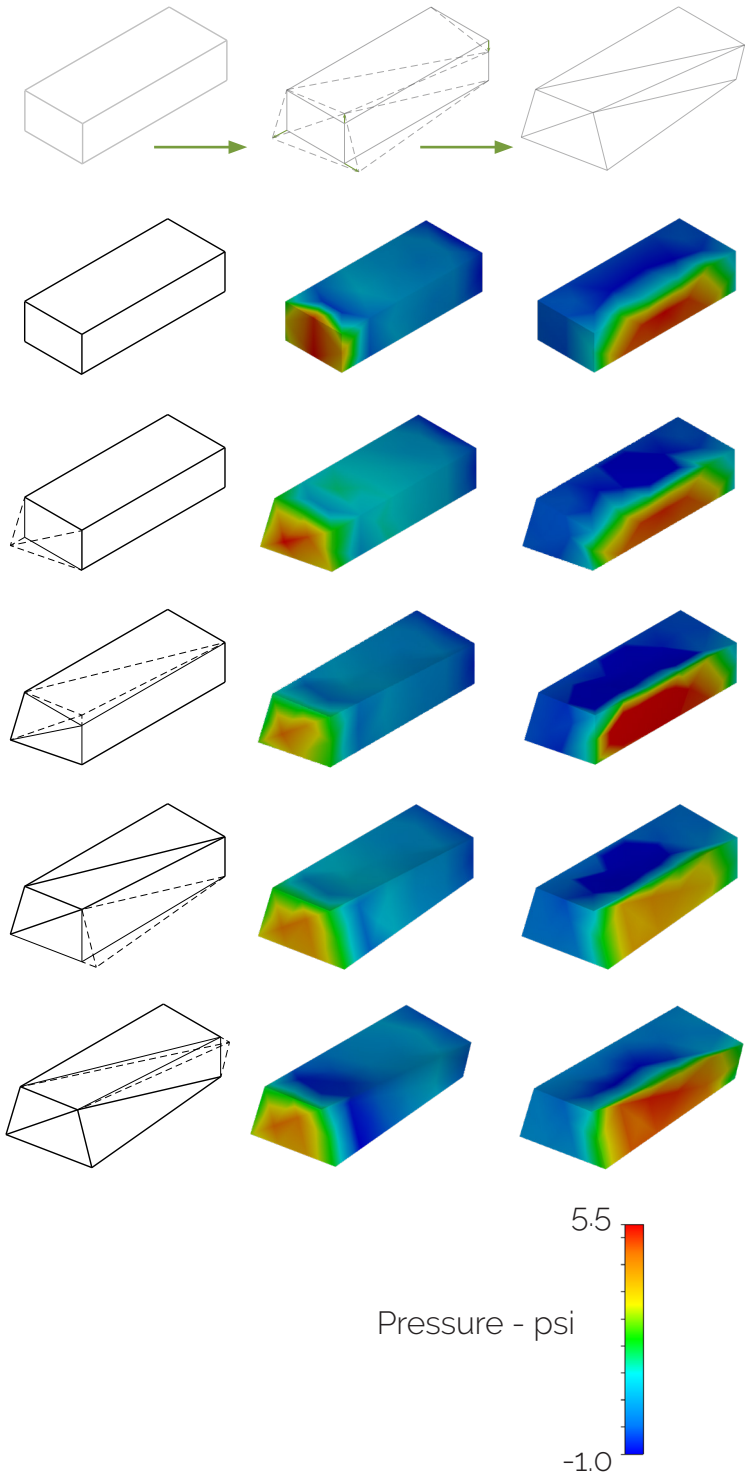
Aerodynamics

Faceted Geometry

The first geometry explored was the pushing and pulling of points on the base form. This resulted in angled surfaces that aimed air movement around the structure.

Wind simulations were used to evaluate different forms for static pressure caused by air movements. All simulations were conducted using 150 mph winds. Simulations were run using Autodesk Computational Fluid Dynamics 2019 simulation software.

This type of geometry was evaluated in two directions - front and side. This type of geometry allowed for effective use of form, but overall did not support the shared structure of the multi-unit designs.

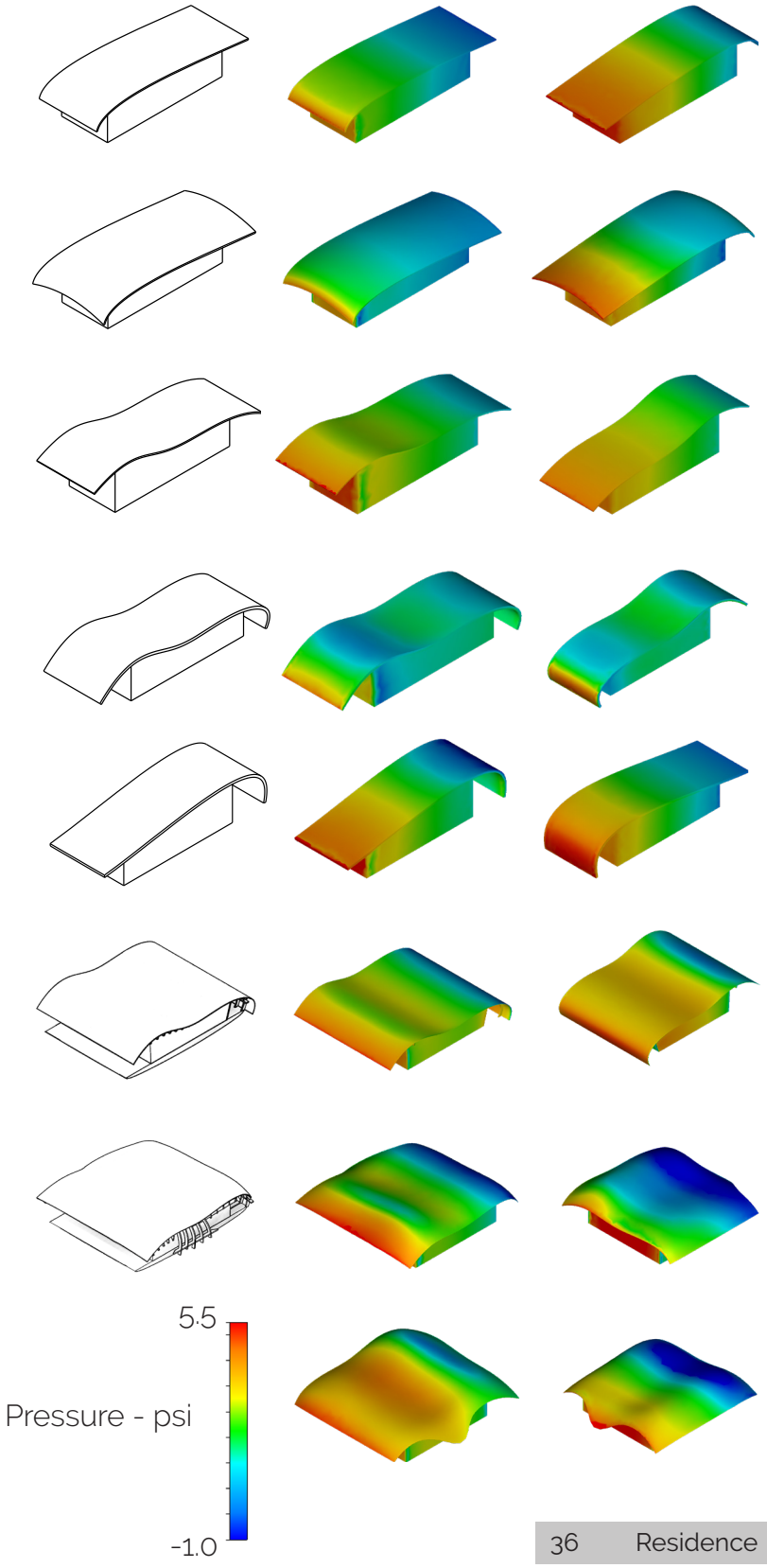


Aviation Geometry

The second geometry explored was based on the form of aviation designs. Aircraft wind sections served as the main inspiration for the roof structures that were analyzed. This geometry allows for a shared roof structure between units.

These designs were analyzed from the front and back directions, Forms evolved into wrapping the roof form around the back of the design to move air above and below.

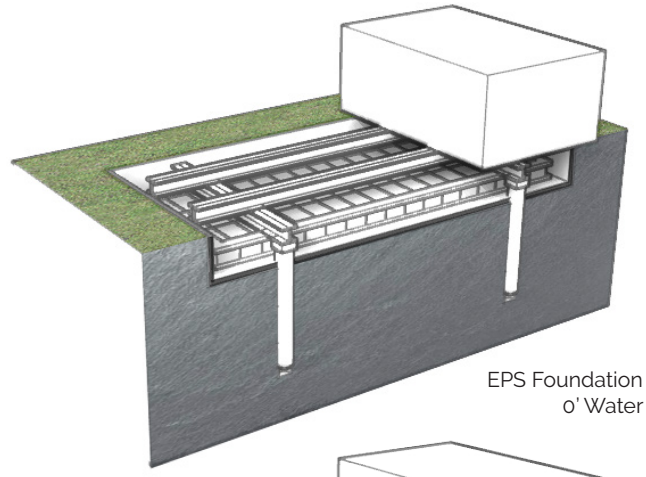
The aerodynamics were then tested on the form applied to the two-unit structure. The roof structure was then curved down the sides of the structure to test aerodynamics on all four sides of the structure.



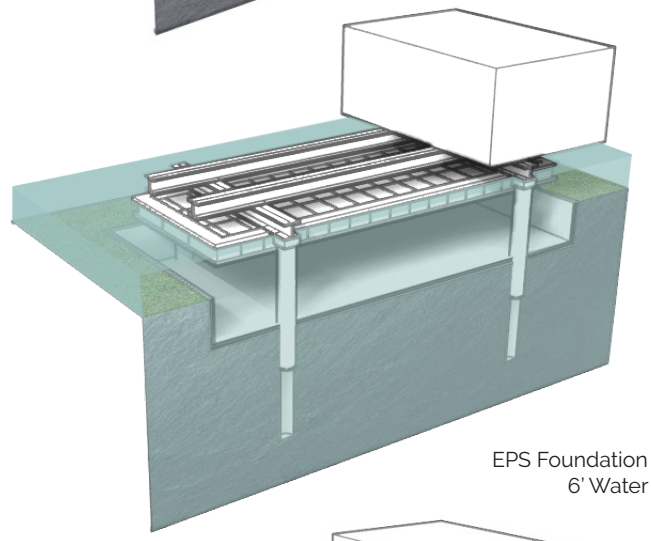
Amphibious Foundation

There are two types of amphibious foundations that were considered for this structure. The first is based on using Extruded Polystyrene Blocks placed under the structure. These blocks float, raising the structure when exposed to water. This style is often used to change existing homes into amphibious structures. It is typically used for light weight construction.

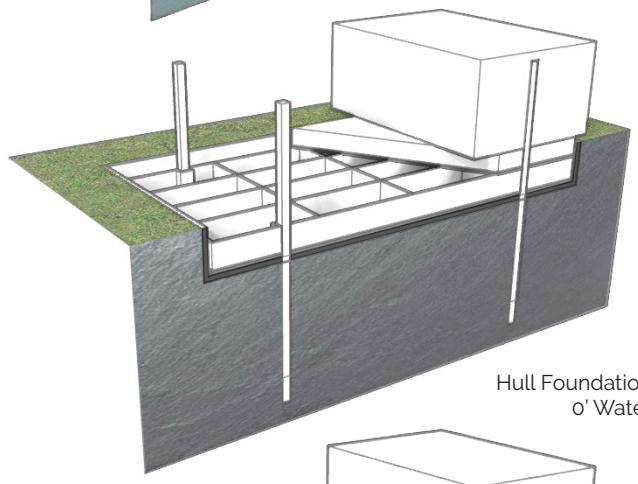
The second is a concrete hull method. It involves having a hull under the structure that contains a grid of concrete that traps air. The trapped air is what makes the concrete buoyant. The building is kept above the water level because the hull is designed to have the proper proportions of concrete versus air to counter the dead and live load of the structure. This has been used for larger homes and heavier weight construction projects as seen in the precedents.



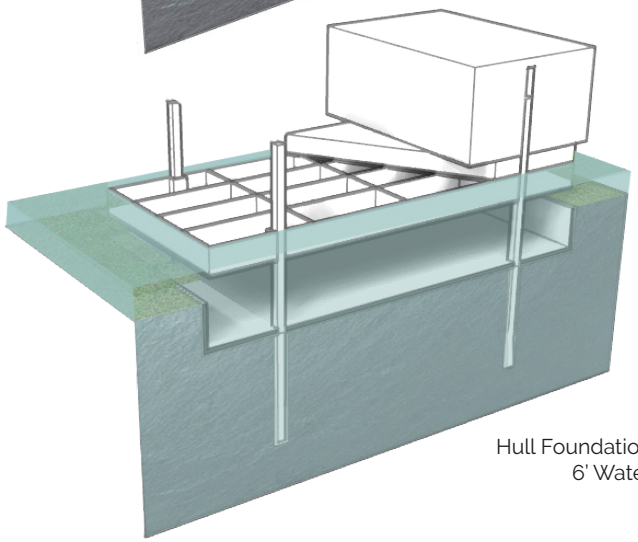
EPS Foundation
0' Water



EPS Foundation
6' Water



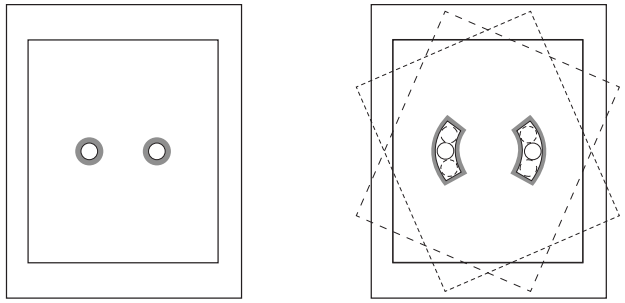
Hull Foundation
0' Water

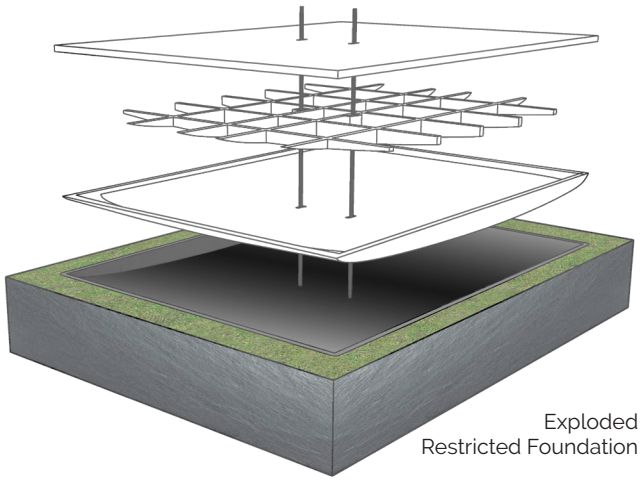


Hull Foundation
6' Water

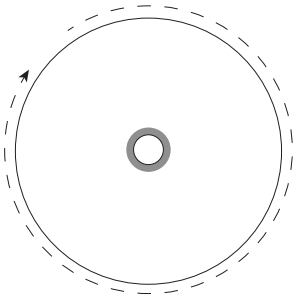
By utilizing the concrete hull amphibious design, the structure can be utilized and use two guideposts to settle the building back to its original position. The two posts restrict movement to a vertical change only. This does not allow for movement caused by wind or water. To account for water and wind pressure, tracks were applied to the guideposts, giving the structure a rotational tolerance. Based on factors in the floor plans and structure only an 18-degree tolerance was achieved.

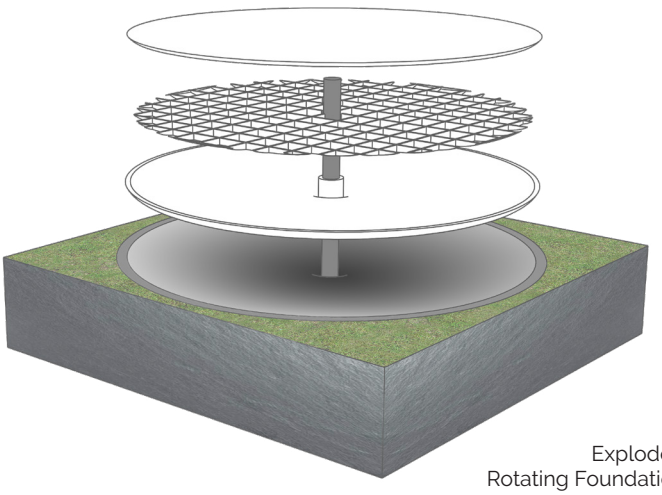
By changing the foundation shape to a circular design has 360-degree tolerance to wind and water movement. This utilizes a single central guidepost to maintain the structure's position. The concrete hull and air method is used, but the foundation size must be larger to accommodate the footprint of multiple units.





Exploded
Restricted Foundation

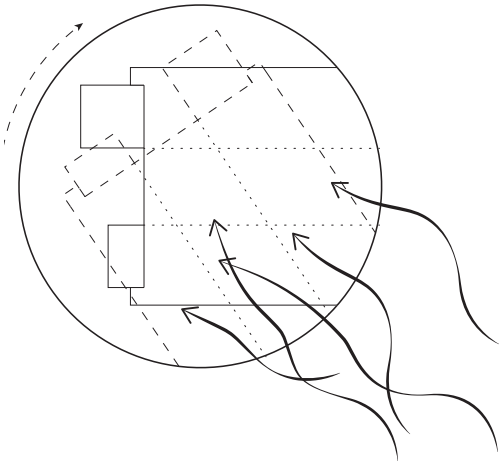




Exploded
Rotating Foundation

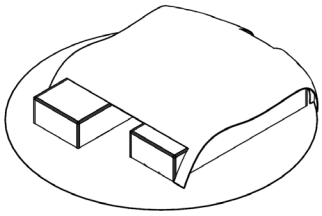
Comprehensive Form

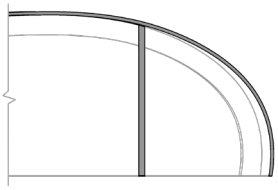
With the foundation being circular, the form was revisited to be cohesive with the foundation form. The rotational mechanism is controlled by wind pressure rotating the structure. Given the rotational ability of the design, the structure's form only needed to be evaluated for aerodynamics in two directions.

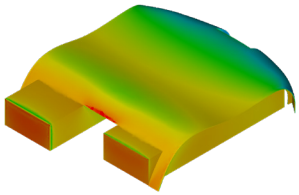


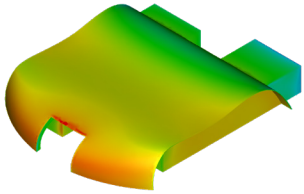
Wind Controlled Rotation

The first redesign used the forms previously explored and created a circular form to connect with the foundation. It also extends the negative space between the units through the shell form.

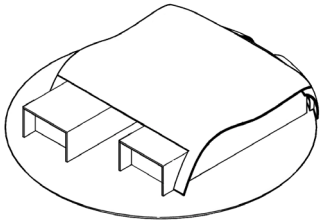


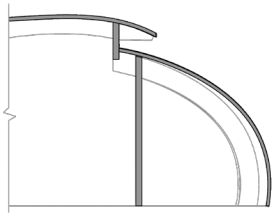


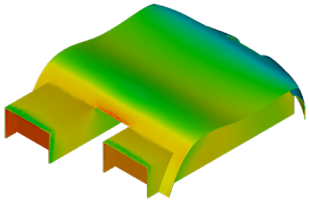


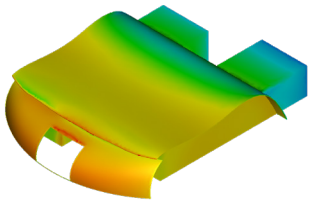


The final rendition evaluated overhangs on the units and a break in the shell.

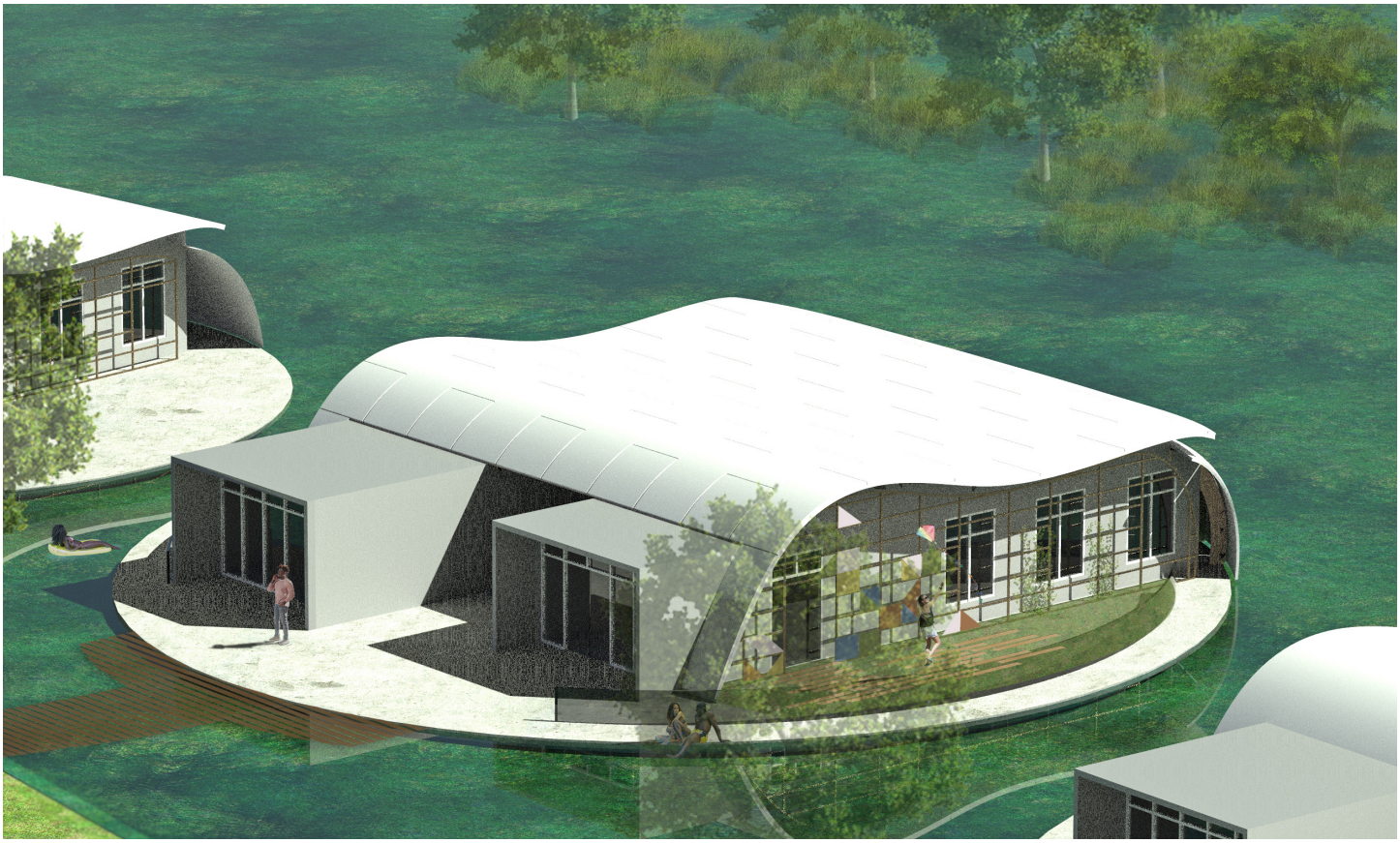








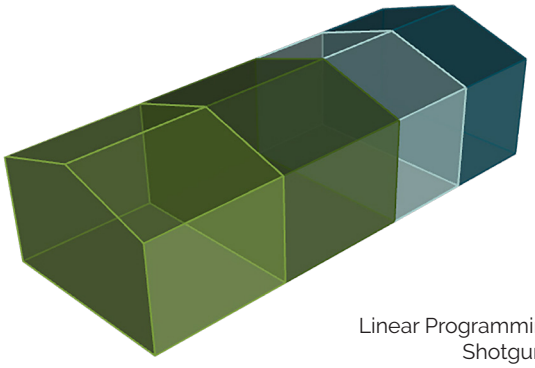
0' of Water



7' of Water

Unit Schematics

The layout of individual units is reminiscent of the traditional shotgun style home. It involves the program of the unit being arranged in a linear fashion, with a straight circulation space serving as a datum through the unit.



Linear Programming of a Shotgun Style

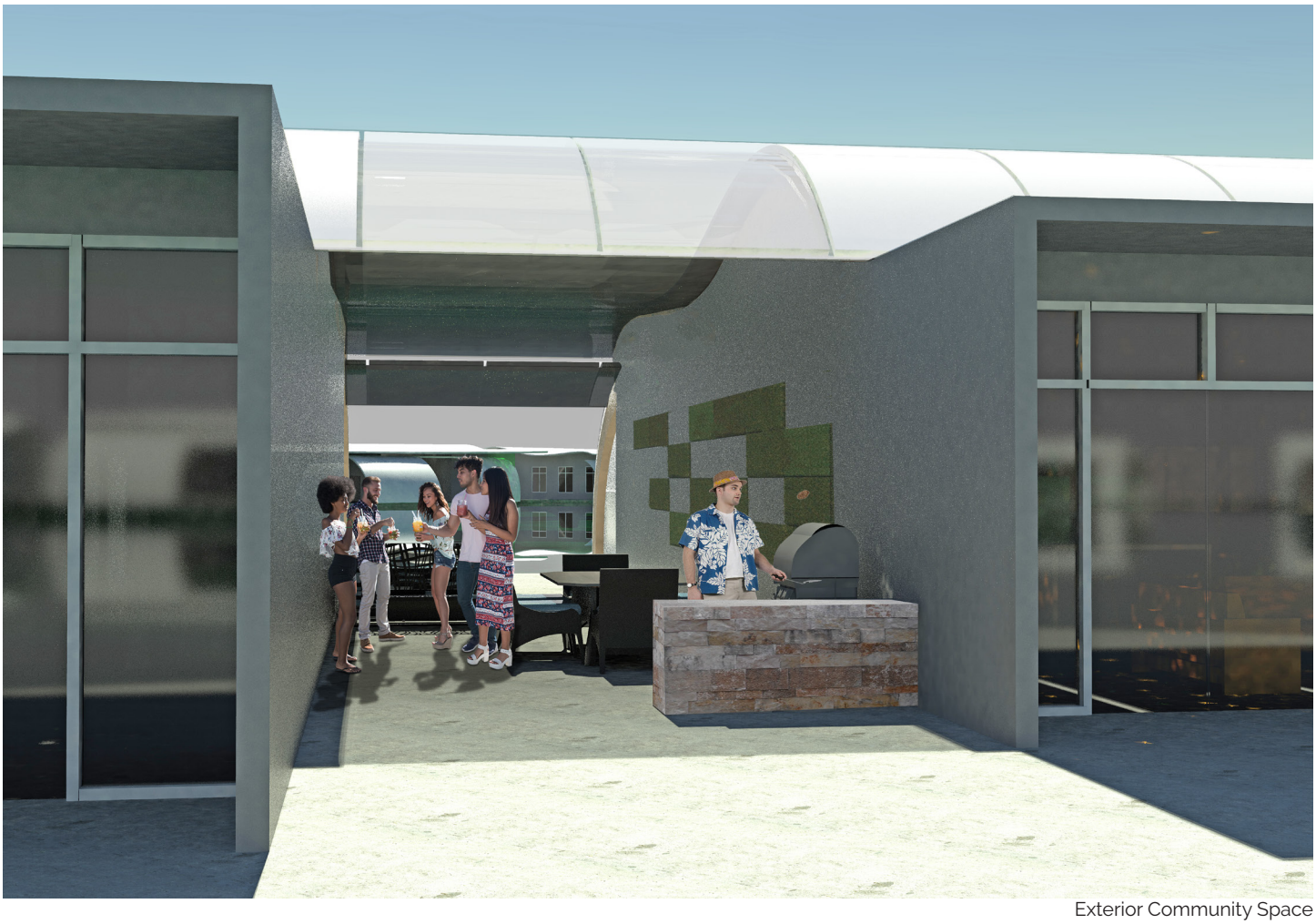
Program:

A. Living Room | ~258 sqft
B. Kitchen | ~108 sqft
C. Dining Room | ~50 sqft
D. Bedroom | ~106 sqft
E. Master Bedroom | ~158 sqft
F. Bathroom | ~43 sqft
G. Laundry Facility & Mechanical | ~62 sqft

`

Site & Floor Plan

Experience



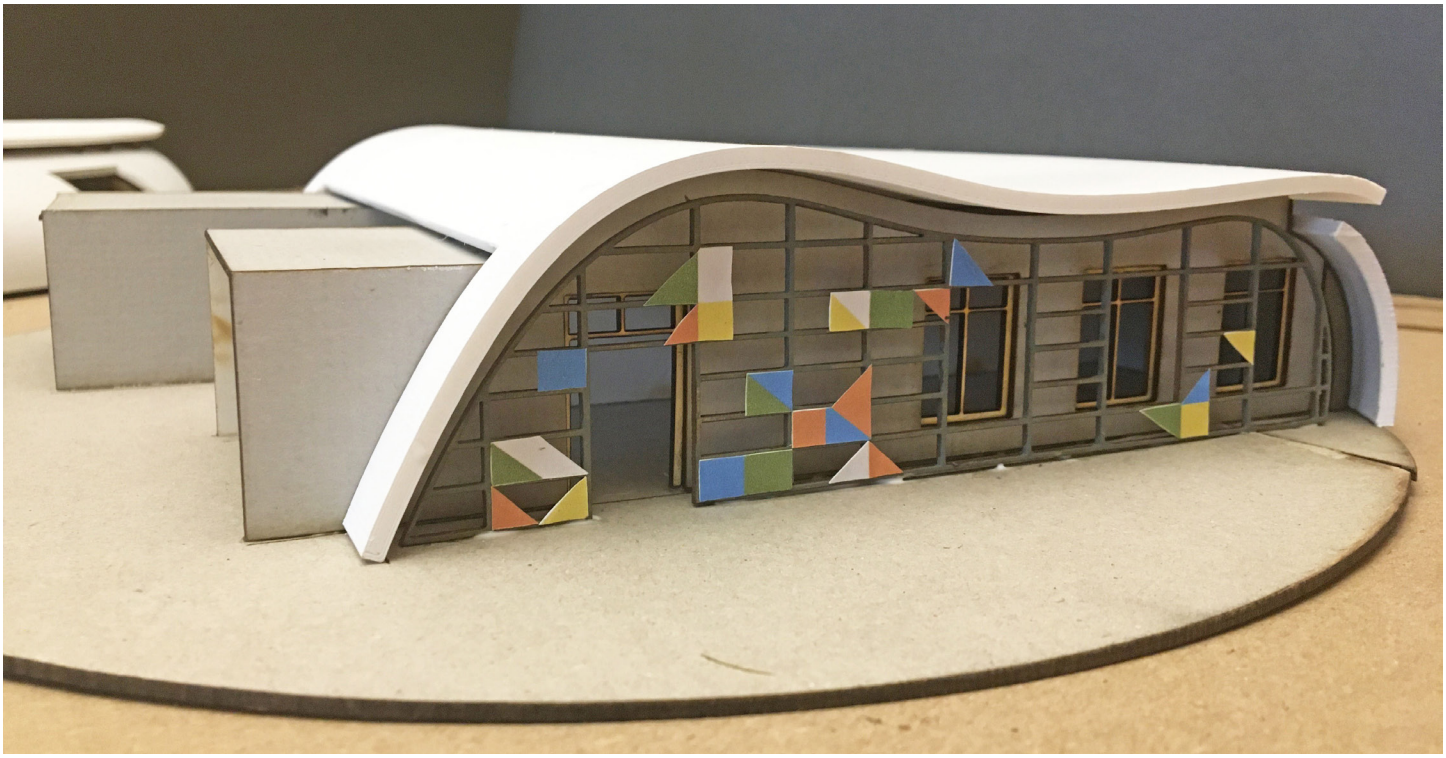
Exterior Community Space

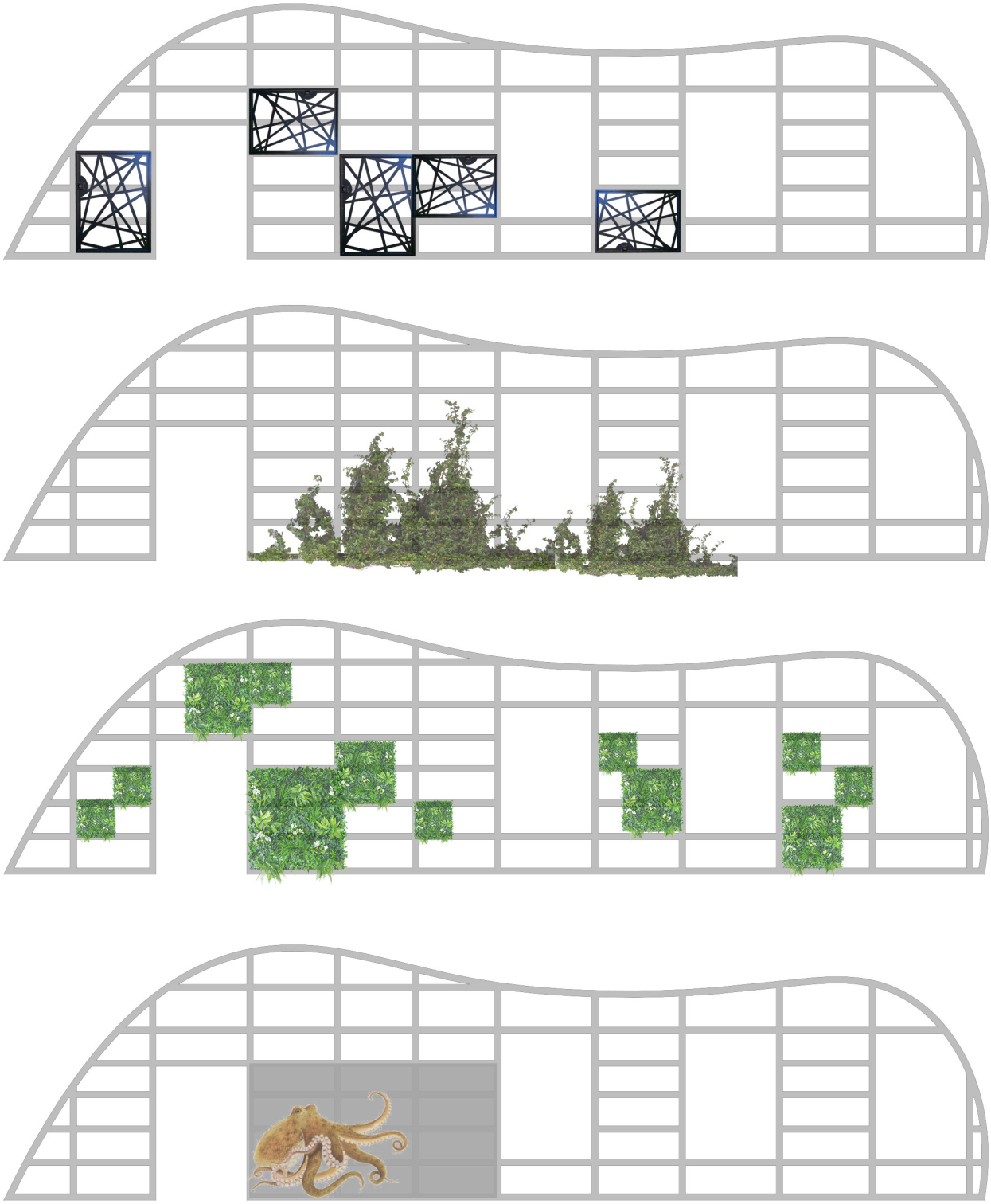
Main Interior Space

Exterior Customization

Within communities, people have individuality. To promote individuality, and support for different art styles and hobbies, a trellis is applied. This also helps create a barrier between debris and the unit.

The trellis can support artistic panels, garden squares, art mediums, and support for ivy and vegetable plants.



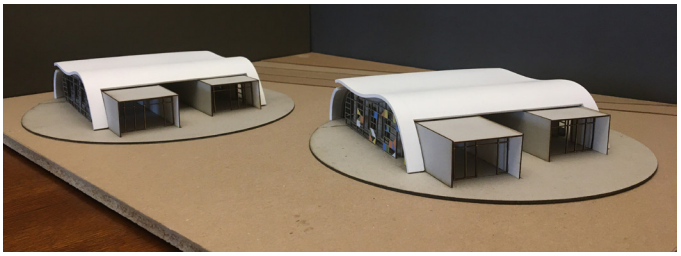


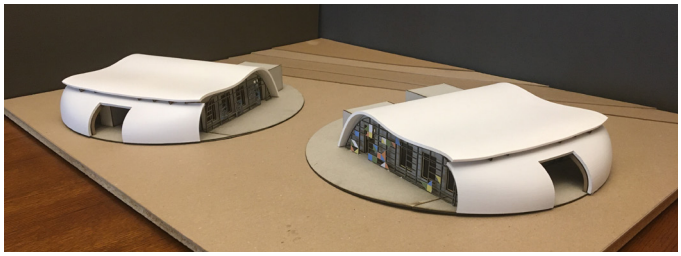
Rotational Foundation Structure

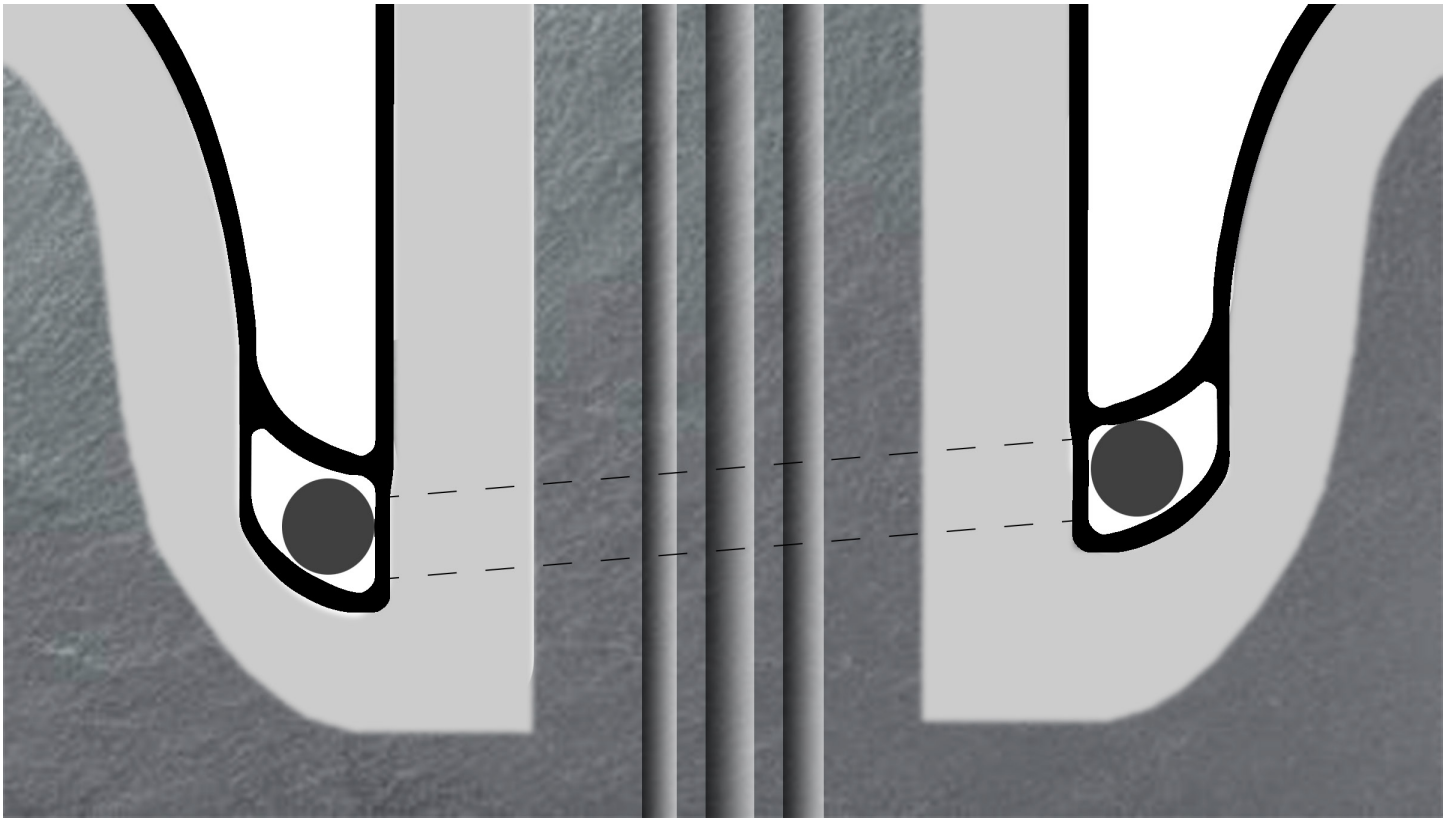
To accommodate the rotational factor of the foundation, the design needs to return to its original orientation. This is the orientation that allows for the buildings to face the street. By having a low point in the hull design, where one side is deeper, the building will naturally settle so the low points connect,

Each unit rotates independently. While theoretically they should typically be oriented the same, during severe storms and high winds they can rotate based on the varying wind directions.

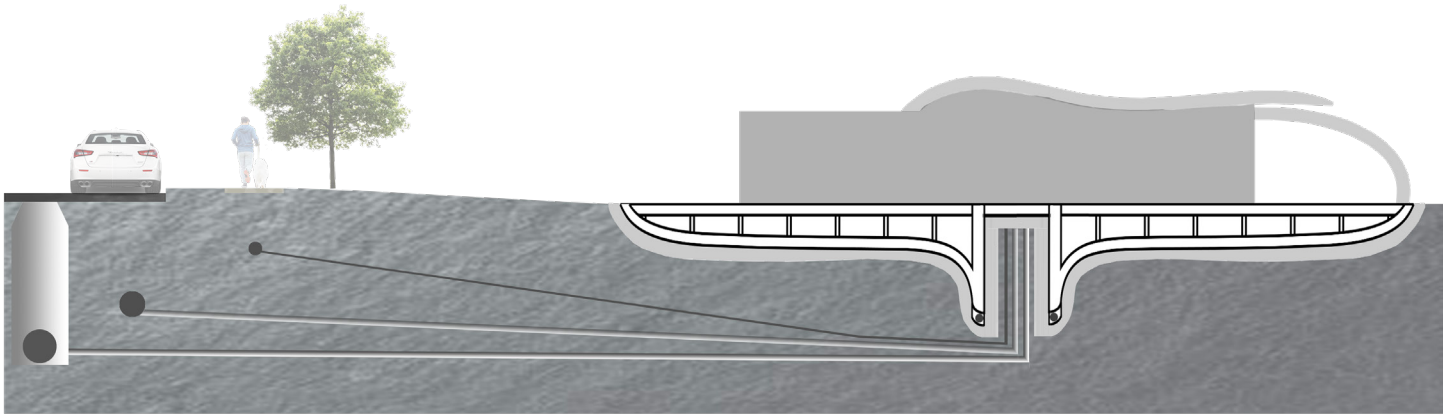
Connecting each unit to utilities requires flexible connections with faceted and rotating joints. The central guidepost is hollow allowing utilities to travel underground from supplies up through the guidepost to the top slab and into the units.





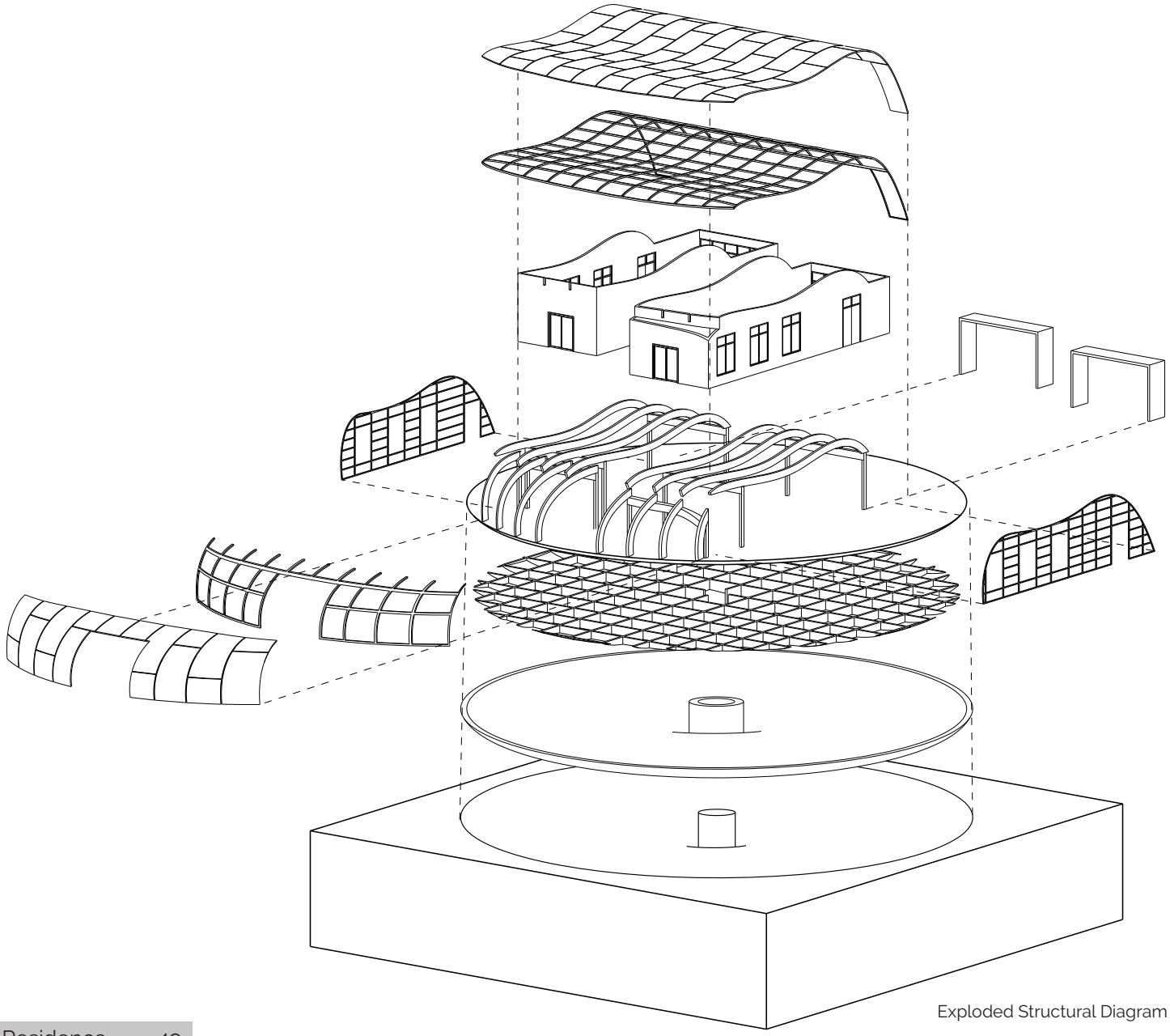


Rotational Foundation Mechnaism



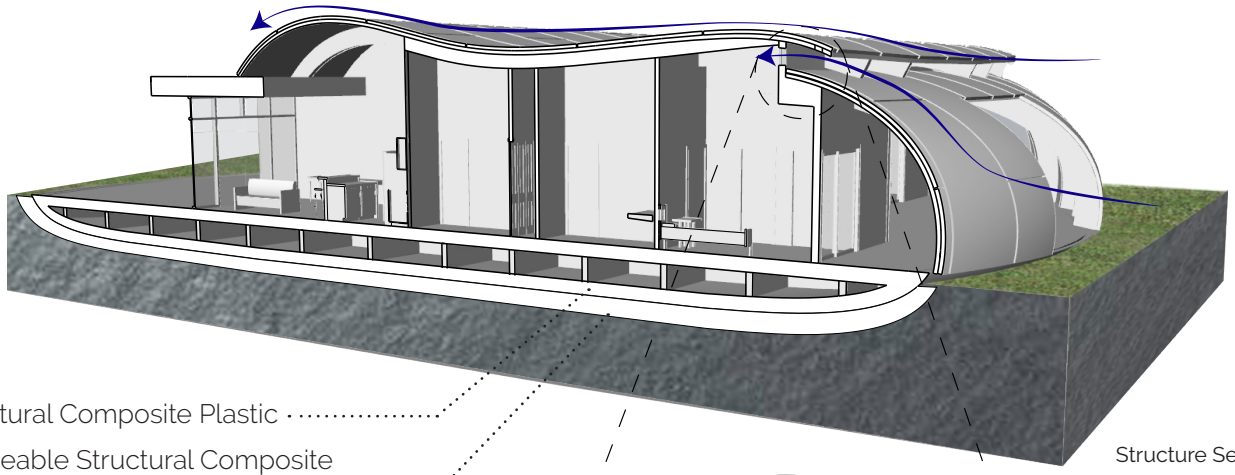
Foundation Section & Utility Connection

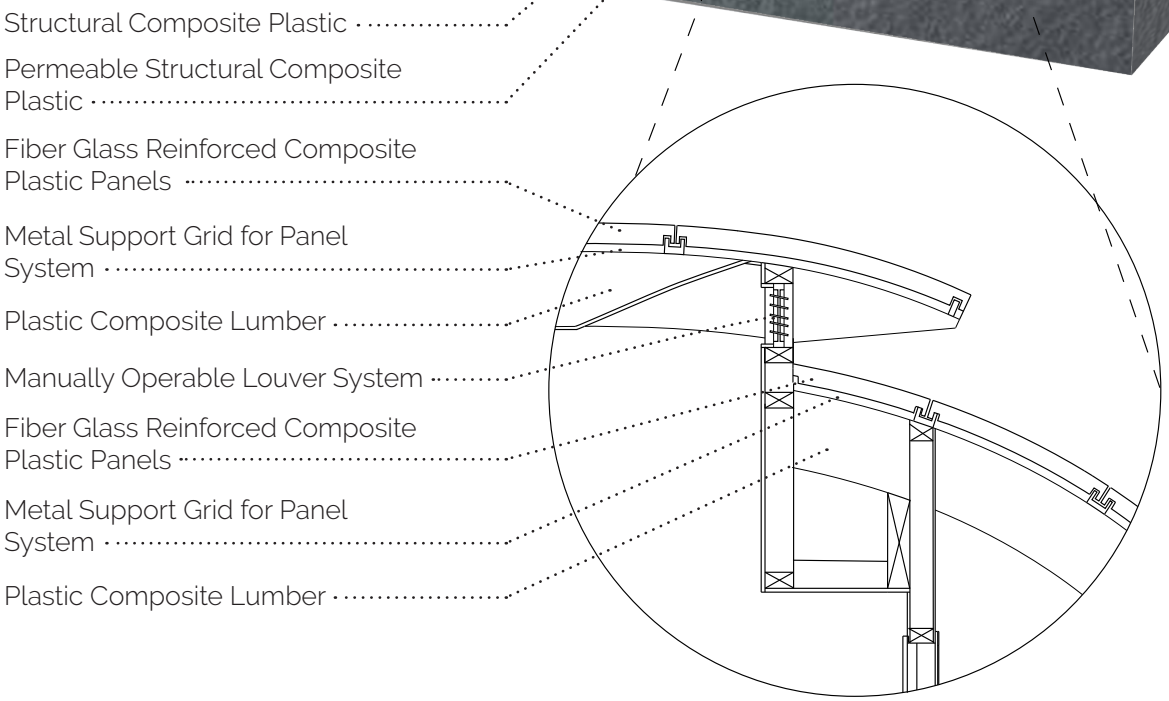
Structure



Exploded Structural Diagram

The structure of the design utilizes plastic as the leading material. Structural plastic can be made from recycled plastics and will not break down when exposed to water for long periods of time. It is lightweight, reducing deadloads of the structure, and it can be formed into custom shapes.





Structure Section & Detail

Conclusion

Project Reflection

This community prototype concept serves as a design that can be applied to coastal areas throughout the world. Other coastal communities could mimic the comprehensive forms of this community or be designed using the basic concepts and goals as the framework for applications with additional design challenges. The community prototype presented offers a potential solution for a single coastal area with specific conditions and cultures.

By understanding and addressing the inevitable likelihood of architecture encountering floodwaters, design compensates for the fluctuating water line, and can promote the use of the community throughout the flood seasons. It also allows the design to be effective for the future. As sea levels rise, the community will still be occupiable, preserving it for the foreseeable future.

A sequence of time lapses and aerodynamic simulation helped to estimate the successfulness of these designs. While full hurricane simulations were beyond the software capabilities, the wind simulations offered insight into how different modifications of a form could change static pressure. The change is weighing the option between lower maximum pressure over a large area, or higher maximum pressure at a single point.

These are still many concepts and design elements this design could explore. While the site can be occupied when encountering a 7' flood, how could the design be occupied beyond that threshold? The community is not designed to be occupied during severe storms such as hurricanes but how could that be possible. This project could push the boundaries of the occupiable conditions and expand on the community potential.

The community pattern could be further explored as well. The pattern aimed to help move water in an efficient manner around infrastructure. This pattern was determined before the rotational foundation was considered. Now that the buildings are round, creating an efficient form for water to move around, the community design would explore new patterns as it's original intent has been resolved at the residence scale.

At the residence scale, more evaluation should be conducted to

determine the success of the wind rotating the structure. One concept to explore in the future is the form shell to be independent form the units, where the shell could rotate free of the units. This would result in a more lightweight element with less resistance to wind, and the units could always be oriented towards the street, maintaining the street culture.

The final major element to explore would be to address the concern about cost. Budget was never in the scope of this project, but the Lower 9th Ward is a very low-income area. These designs would never be affordable for the residents. While the design would greatly change, exploring how to value engineer the design to make the project affordable with the aid of government funding. While the design and materials would be simplified, the importance would be maintaining the concepts and bettering the community environment.

Personal Reflection

This project offered a lot of challenges that changed my personal approach to the design process. This project required a lot of back and forth between different components. While it took longer to finalize an element of design overall the design was cohesive. Typically, after I finish a design whether it be the floor plan, elevation, etc. I am hesitant to change the overall design to where the completed elements would need to be changed. For this project as the form continuously changed, so did the floor plans and elevation design. There was also significant back and forth between the site design and residence design that normally does not occur in my process. While it required mor dedicated time, the project was much better off.

This project had a different approach to any I have done before. This design was performance and data driven, while my designs are typically experienced driver. This was a challenge to overcome, because decisions were being made that would have profited experience over performance, so those decisions had to be back tracked once acknowledged. The other major challenge in design decisions was performance over aesthetics. While the goal is for the building to fulfill certain performance criteria, there is still a desire for the design to be aesthetic. Certain decisions were made that benefitted the aesthetics over the performance, but the challenge involved balancing these two concepts.

Designing the community presented as a challenge. I expected it to be a different experience since it pulls more on urban planning and I do not have much experience with that field. It was difficult to get through those areas of the project. The changing factor was realizing that the process is similar to that of designing a building, the chosen concepts are just applying to a larger scale, therefore they must also be at a larger scale. Overall, this project was exciting. It went in a completely different direction than what was expected, but that is what makes the process successful – pushing designs into ways you would not have imagined. I have been more passionate about this project that any other. I have learned new software, new methods of design, and new fabrication methods.

Overall, this project was exciting. It went in a completely different direction than what was expected, but that is what makes

the process successful – pushing designs into ways you would not have imagined. I have been more passionate about this project that any other, maybe because it embraces nature and my landscape architecture experience was useful. I have learned new software, new methods of design, and new fabrication methods. While the abstract and custom design of these structure will not be common in the industry, the concepts and methods the form derived from will be applicable to my future experience in the workforce.

Figure Credits

1. Adapted From: *Flood Map of New Orleans.* October 2005. *ResearchGate.* https://www.researchgate.net/publication/327022940_Hurricane_Katrina_Storm_Damage_Survey.

2. *Levees in the Greater New Orleans Area and Failures During Katrina.* 2006. *Science Education Resource Center Carleton College*. https://serc.carleton.edu/integrate/teaching_materials/coastlines/student_materials/1086. Figure 9.10

3. Tanya Lukasik. *{New Orleans} Musicians Village Rainbow Row*, August 1, 2008. Flickr accessed April 2, 2020 https://www.flickr.com/photos/27217934@N04/2724324298/

4. Tom Caswell. *Awesome street band in New Orleans.* July 15, 2012. Flickr accessed April 2, 2020 https://www.flickr.com/photos/caswell_tom/7576633398/

5. carnagenyc. *Boans.* July 10,2009. Flickr accessed April 2, 2020 https://www.flickr.com/photos/sabeth718/3749268276/

6. *Relative Sea Level Trend.* National Oceanic and Atmospheric Administration accessed November 15, 2019 https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8761927

7. *Average Seasonal Cycle.* National Oceanic and Atmospheric Administration accessed November 15, 2019 https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8761927#tabscenario

8. Franco Folini. *Erosion.* February 18, 2007. Flickr accessed April 29, 2020 https://www.flickr.com/photos/livenature/412133673/